FEB 26 1929

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C. 2.

VOL. CXLVII.—No. 3813] LONDON: FRIDAY EVENING, FEBRUARY 8, 1929 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

The Engineer

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PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, London, S.E. 1, invites TENDERS for—

ONE 156ft. Span of BRIDGEWORK.

Tenders due 20th March, 1929.

Forms of Tender available from the above at a fee of 5s., which will not be returned. 938

Air Ministry.
DIRECTORATE OF SCIENTIFIC RESEARCH.

A JUNIOR SCIENTIFIC OFFICER is REQUIRED for the AIR MINISTRY SCIENTIFIC RESEARCH STAFF, primarily for duty at the Royal Aircraft Establishment to assist with Research Work in the Aerodynamics Department.

Candidates should have a First-class Honours Degree in Mechanical or Natural Science, and Aeronautical Training or Experience would be an additional recommendation. Candidates must also be medically fit for flying duties and be willing to fly as observer.

The post will carry superannuation under the Federated Universities' Superannuation System. Government contribution being 10 per cent. of mean of scale; individual contribution, 5 per cent.

Salary £175, rising by annual increments of £15 to £235, plus Civil Service Bonus per annum, giving a present total starting remuneration of £250 9s. per annum.

Preference given, other things being equal, to ex-Service men.

Application should be made on a form to be obtained from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned, quoting reference No. A. 319, not later than 2nd MARCH, 1929. 917

Air Ministry.
DIRECTORATE OF TECHNICAL DEVELOPMENT.

A DESIGNER is REQUIRED at the Royal Aircraft Establishment, primarily for work in connection with the design and maintenance of Works Plant.

Candidates must have had a sound technical training, first-class experience of Steel Structural and Mechanical Engineering, in a responsible design position, and must be capable of making stress calculations.

Experience in estimating and surveying is desirable.

Preference given, other things being equal, to an ex-Service man.

Commencing salary £250 plus Civil Service bonus per annum, giving a present total remuneration of £353 4s. on the scale £250-£15-£350 plus Civil Service bonus per annum.

Application should be made on a form to be obtained from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned (quoting reference No. A.321) not later than 22nd February, 1929. 931

Crown Agents for the COLONIES.
COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POST:—

M/906.—WATERWORKS ENGINEER REQUIRED by the GOVERNMENT of NIGERIA, for the PUBLIC WORKS DEPARTMENT, for two tours of 12 to 18 months' service, with possible extension. Salary £800, rising by annual increments of £40 to £920 a year; seniority allowance of £72 a year whilst on duty in the Colony. Free quarters, passages and liberal leave with full salary. Candidates, between 30 and 40 years of age, must possess a thorough knowledge of and experience in Design and Construction of Waterworks, and in the Investigation of Water Supplies in the Tropics and elsewhere. Must be Corporate Members of the Institution of Civil Engineers.

Apply at once by letter, stating age and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/906. 916

The Government of INDIA REQUIRE TWO INSPECTORS OF STORES (STRUCTURAL)

for service in the Indian Stores Department. Candidates must possess a University Degree in Engineering or good general education up to the standard of the Institution of Civil Engineers or of the Institution of Mechanical Engineers, and drawing-office experience, and have served a regular apprenticeship in structural engineering workshops. It is essential that they should have specialised in structural steel and bridge work. Age preferably between 24 and 33 years of age.

Agreement for five years in the first instance. The scale of pay applicable to both appointments is Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 a calendar month, with a personal allowance of Rs. 200 a month and certain other allowances. The selected candidates will be granted a commencing rate of pay within this scale commensurate with their age and qualifications. Free first-class passage to India. Provident Fund.

Further particulars and forms of application may be obtained upon request by postcard to the SECRETARY TO THE HIGH COMMISSIONER FOR INDIA, General Department, 42, Grosvenor-gardens, London, S.W. 1. Last date for receipt of applications 23rd February, 1929. 891

Armstrong College,
NEWCASTLE-UPON-TYNE.
(IN THE UNIVERSITY OF DURHAM.)

COURSES for the PASS DEGREE of B.Sc. and the HONOURS DEGREE of B.Sc. in MECHANICAL, MARINE, CIVIL or ELECTRICAL ENGINEERING, MINING, METALLURGY, or NAVAL ARCHITECTURE. The curricula of the Pass Degree and the Honours Degree normally occupy periods of three and four years respectively, but candidates presenting evidence of sufficient previous training may be allowed to proceed to either Degree after two years' residence.

The engineering laboratories have recently been extended, and all Departments are equipped for advanced tutorial and research work.

Full particulars of the Courses may be had on application to

THE REGISTRAR,
Armstrong College,
223 Newcastle-upon-Tyne.

LONDON ASSOCIATION OF FOREMEN ENGINEERS
(FOREMEN, MANAGERS and EMPLOYERS)
connected with Engineering Industry.

Seventy-sixth Anniversary Festival,

CANNON STREET HOTEL,

SATURDAY, MARCH 2nd, 1929,

CHAIRMAN:
SIR FREDERICK D. GREEN.

Tickets 15/- each.

To be obtained from the SECRETARY, 36, GAYTON ROAD, HARROW. 746

University of London.

A COURSE of FIVE LECTURES, with lantern illustrations, on "HIGH-VOLTAGE CABLES," will be given (in English) by Mr. L. Emanueli (of Milan, Chief Electrical Engineer of the Pirelli Cable Manufacturing organisation), at the INSTITUTION OF ELECTRICAL ENGINEERS (Victoria Embankment, W.C. 2), on FEBRUARY 20th, 22nd, 26th, March 1st and 5th, at 5.30 p.m. At the first Lecture the chair will be taken by Professor C. L. Fortescue, O.B.E., M.A., M. Inst. C.E., M.I.E.E. (Dean of the Faculty of Engineering in the University).

ADMISSION FREE, WITHOUT TICKET.

EDWIN DELLER,
913 Academic Registrar.

PUBLIC NOTICES

Bradford Education Committee
TECHNICAL COLLEGE.

APPLICATIONS are INVITED for APPOINTMENT as HEAD of the DEPARTMENT of CIVIL ENGINEERING, ARCHITECTURE and BUILDING in the College.

The scale of salary attached to this appointment will be £600 to £700 per annum.

Full particulars of the appointment and forms of application may be obtained from the Director of Education, Town Hall, Bradford, and completed forms should be returned to the Principal of the College not later than 23rd February, 1929.

889 THOS. BOYCE, Director of Education.

Administrative County of LONDON.
REMOVAL OF SEWER DEPOSIT.

The London County Council invites TENDERS for the REMOVAL and DISPOSAL of SEWER DEPOSIT and other MATERIALS in connection with the main drainage, &c., services for four districts, two north of the Thames and two south of the Thames, east and west respectively, for a contract of twelve months, commencing 1st April, 1929.

The specification, form of Tender, &c., may be obtained on application to the Chief Engineer, the Old County Hall, Spring-gardens, S.W. 1, upon payment of £1 by cheque, draft or money order to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before payment of the fee.

Remittances by post should be addressed to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1. Personal inquiries at Room 3A at No. 3, Warwick House-street, Cockspur-street, S.W. 1.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in "The London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 25th February, 1929, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
910 Clerk of the London County Council.

PUBLIC NOTICES

Royal Show.

HARROGATE
JULY 9th to 13th, 1929.

EXHIBITION OF IMPLEMENTS, &c.

The Regulations and Forms of Application for Space are now ready.

Applications for space must be made by
WEDNESDAY, MARCH 20th, 1929.
ENTRIES for Silver Medal close March 1st.

Live Stock (except Riding and Driving Horses) entries close on MAY 1st; Riding and Driving Horses on MAY 31st; Produce and Forestry on MAY 20th; Flower Show on MAY 29th; Poultry and Butter Making Competitions on MAY 31st; Plantations, Home Nurseries, Orchards and Fruit Plantations on MAY 1st.

T. B. TURNER, Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND,
16, Bedford Square, London, W.C. 1.

Administrative County of LONDON.
SCAVENGING, &c., OF THAMES EMBANKMENTS AND BRIDGES.

The London County Council invites TENDERS for the SCAVENGING, &c., of, and the SUPPLY and DELIVERY of GRANITE CHIPPINGS, SHINGLE and SAND to the Thames Embankments and Bridges for a period of twelve months commencing 1st April, 1929.

The form of Tender, &c., may be obtained on application to the Chief Engineer, the Old County Hall, Spring-gardens, S.W. 1, upon payment of £1 by cheque, draft or money order to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before payment of the fee.

Remittances by post should be addressed to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, personal inquiries at Room 3A at No. 3, Warwick House-street, Cockspur-street, S.W. 1.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in "The London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 25th February, 1929, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
933 Clerk of the London County Council.

County Borough of Tynemouth.

TENDERS to CONSTRUCT, in Cement Concrete, an APRON WALL of about 250 yards in length upon the foreshore to defend the cliffs against the sea, are INVITED.

The drawings, &c., can be seen and (upon payment of Five Guineas) copies of the general conditions, specification and bills of quantities, and forms of Tender obtained at the office of Mr. John F. Smillie, Borough Surveyor, Howard-street, North Shields. (The Five Guineas will be repaid if a bona fide Tender be submitted and upon the copies of the general conditions and the specification being returned.)

Tenders, which must be upon the form aforementioned and enclosed in sealed envelopes endorsed "Tender to Construct Apron Wall," are to be delivered at the office of the undersigned by, at latest, 9.30 a.m. on Monday, the 18th February, 1929.

No pledge is given to accept the lowest or any Tender.

STANLEY WILSON,
Town Clerk.

Town Clerk's Office,
Northumberland-square, North Shields,
1st February, 1929. 886

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PUBLIC NOTICES

Goole Urban District Council.

TO BOILERMAKERS.

TENDERS are INVITED for the SUPPLY, DELIVERY, and FIXING of a STEEL CORNISH BOILER, about 21ft. long by about 5ft. 9in. dia., complete with all mountings and fittings.

TENDERS are INVITED ALSO for the SUPPLY and DELIVERY to site of a STEEL VERTICAL BOILER, about 3ft. 3in. dia. by about 7ft. 6in. high, working pressure 80 lb. per square inch, complete with all mountings and fittings.

Forms of Tender and specification can be obtained, and conditions of contract seen, upon application to Mr. J. H. Castle, Engineer and Surveyor, Council Offices, Goole.

Sealed Tenders, endorsed "Boilers," addressed to the Chairman of the General Purposes Committee, are to be delivered to the undersigned by Twelve Noon on Wednesday, 20th February, 1929.

The Council do not bind themselves to accept the lowest or any Tender.

J. W. PULLON,
Clerk to the Council.

Council Offices,
Goole,
4th February, 1929. 919

Government of Northern Ireland.

BANN DRAINAGE SCHEME.

NOTICE TO CONTRACTORS SPECIALISING IN THE DESIGN, MANUFACTURE AND ERECTION OF FLOOD GATES.

The Ministry of Finance invites DESIGNS and ESTIMATES of COST for the PROVISION and ERECTION of FLOOD GATES in Toome, Portna, and The Cutts Navigation Weirs on the Lower Bann River.

The accepted Design, with any amendments considered necessary by the Ministry, will be included in the contract for the drainage scheme.

The following are the approximate gate areas required :—

Toome Weir	3510 square feet
Portna Weir	1830 square feet
The Cutts Weir	1660 square feet

Plans, giving full particulars of the discharge capacities required at various levels of the river, maximum lift of gates, particulars of sites, cross and longitudinal sections, and particulars of nature of foundations, &c., can be obtained, on written application, from the Secretary, Ministry of Finance, 15, Donegall-square West, Belfast.

Applications for the plans should be accompanied by a deposit of £10, which will be repaid on return of the plans. Designs and Estimates should be forwarded to the Secretary, Ministry of Finance, not later than the 15th March, 1929.

E. E. THORNLEY,
Assistant Secretary.

Ministry of Finance, Belfast,
23rd January, 1929. 816

Liverpool Corporation Water-Works.

PUMPING MACHINERY.

AUBREY-STREET, LIVERPOOL.

TENDERS are INVITED for the SUPPLY and ERECTION of ELECTRICALLY DRIVEN PUMPING PLANT, consisting of Three Sets of Centrifugal Pumps and Induction Motors, with Automatic Control Gear, at the Aubrey-street Pumping Station, Liverpool. Each set is to be capable of pumping 2500 gallons per minute, against a total head of 110ft.

Copies of the specification and form of Tender can be obtained from Mr. J. R. Davidson, Water Engineer, 55, Dale-street, Liverpool, upon payment of the sum of Two Guineas, which amount will be refunded upon receipt of a bona fide Tender.

The Water Committee do not bind themselves to accept the lowest or any other Tender.

WALTER MOON,
Town Clerk.

Municipal Buildings,
Liverpool, February, 1929. 951

South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of—

1. LOCOMOTIVE BOILERS (TWELVE).
2. MISCELLANEOUS ARTICLES and MATERIALS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Locomotive Boilers," or as the case may be, with the name of the firm tendering, must be left with the undersigned not later than Twelve Noon on Friday, the 1st March, 1929.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of specification No. 1 and of 10s. for each copy of specification No. 2.

Copies of the drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W. 1,
6th February, 1929. 940

The Madras and Southern Mahratta Railway Company, Limited,

invite TENDERS for :—

20,000 BEARING PLATES for Use with 60 lb. or 60 R. F.F. Rails (approximate total weight equals 60½ Tons).

Tenders are due in on Tuesday, 26th February, 1929, by 2 p.m.

Tender form, obtainable at address below ; fee Half a Guinea, which is not returnable.

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Offices :
25, Buckingham Palace-road,
Westminster, S.W. 1. 915

Contractors Wanted to Tender

for ERECTION of SHIPYARD TOWER CRANES ; supply all tackle and accept full responsibility.—Address in first instance, 908, The Engineer Office. 908 A

Park Prewett Mental Hospital, Basingstoke, Hants.

ASSISTANT ENGINEER.

APPLICATIONS are INVITED for the POST of ASSISTANT ENGINEER ; capable of preparing drawings, taking out estimates for Buildings and Improvements ; must have a good knowledge of Steam and Electrical Plant, and able to keep work costs. Salary commencing at £200, with house valued at £30 per annum, rising to £245, subject to satisfactory service.

Age last birthday not to exceed 34 years.

The appointment will be subject to the provisions of the Asylums Officers' Superannuation Act, 1909.

Applications, stating age, experience and qualifications, must be sent to the MEDICAL SUPERINTENDENT on or before Monday, 18th February, 1929, together with copies of three recent testimonials, envelope to be marked "A E." P5474

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, an ENGINEER, Age About 30, with university training, Cambridge preferred. First-class engineering knowledge and capacity for invention and design are essential. To develop new work in a special field for a long-established firm of manufacturing engineers.

Address, stating age, education, full details of training and experience, and enclosing copies of testimonials and references 887, The Engineer Office. 887 A

YARROW HOME and HOSPITAL FOR CHILDREN BROADSTAIRS.

For the Early & Preventive Treatment of Disease & Convalescence after illness.

The Hospital is intended for the children of Members of the Institution of Civil Engineers, the children of architects, artists, authors, clergymen, members of the medical, legal, and other professions, members of scientific societies, officers of the Navy, Army, and Royal Air Force, officers of the Merchant Navy, schoolmasters and university professors.

Accommodation is provided for 50 Boys between the ages of 4 and 12 years, and 50 Girls between the ages of 4 and 14 years. In special cases the age limits may be raised to 14 for Boys, and 16 for Girls.

Fee 21/- per week, or as may be arranged, and travelling expenses.

Particulars can be obtained from the Secretary :—

116, Victoria Street, Westminster, LONDON, S. W. 1.

SITUATIONS OPEN (continued)

ALFRED HERBERT, Ltd., Coventry, REQUIRE TWO GRINDING SPECIALISTS :—
(1) Grinding Wheel Salesman for Birmingham district.
(2) Grinding Machine Specialist, having practical experience of all kinds of Grinding Machines. Must be efficient demonstrator, preferably with selling experience.
Write, giving full details of experience, age, and salary required. 926 A

CAPABLE ESTIMATOR REQUIRED. Must Have thorough knowledge of modern Engineering Production Methods and be able to conduct correspondence.—State experience and salary to DAVID BROWN and SONS (HUDDFD.), Ltd., Park Gear Works, Huddersfield. 903 A

DIESEL ENGINE TESTING.—VACANCY for Competent young ENGINEER in Testing Department.—Reply, giving details of previous experience and technical training, age, salary expected, and when free, J. and H. McLAREN, Ltd., Engineers, Leeds. 927 A

ENGLISH FIRMS DESIRING First-class Energetic REPRESENTATION in Australia in engineering and associated lines, can procure same with firm of undoubted standing in Sydney. Excellent financial and selling record.—Write in first instance to Z.H. 251, care Deacon's Advertising Offices, Fen church-avenue, London, E.C. 3. 584 A

ENGINEER (Heating and Ventilation). Practical and technologist Capable estimating, planning and laying-out. Able to secure maximum efficiency on fuel consumption.—Apply, letter only, full particulars, BRANSTON ARTIFICIAL SILK CO., Ltd., Burton-on-Trent. 742 A

ERECTORS.—CRANE ERECTORS WANTED for Cantilever Crane Work. Only those with outside experience of this work need apply. State experience and wage expected.—Address, 907, The Engineer Office. 907 A

FOUNDRY MANAGER REQUIRED for Engineering Works in the Midland district.
Must be thoroughly conversant with Sand and Loam Moulding and competent to produce castings to stand pressure for chemical and general engineering work, with up-to-date productive methods at economical cost.
Keen organiser and disciplinarian essential.
Business connection for heavy castings desirable.
Address, giving age, experience, and salary required. 893, The Engineer Office. 893 A

GOOD OPENING for Energetic ENGINEER Used to Selling Centrifugal Pumps: State age, experience, and salary required.—Address, 936, The Engineer Office. 936 A

LIFT ESTIMATOR, with Knowledge of Lay-outs, able to efficiently handle sales correspondence and take charge. State experience and salary required.—Address, 912, The Engineer Office. 912 A

MACHINE TOOL REPRESENTATIVE REQUIRED for Midlands ; good opening for smart practical man with good connection. Applications (in strictest confidence) must state full particulars, training, experience, age, salary, &c.—Address, 934, The Engineer Office. 934 A

MECHANICAL ENGINEERS, Reference Box No. M. 389, c/o Willing's.—APPLICANTS are hereby informed that this VACANCY has now been FILLED. P5469 A

RATE FIXER, ASSISTANT, REQUIRED ; Must be conversant with Machine and Erection of Large Oil Engines.—Apply, stating age, experience, and salary required, to PETTERS, Ltd., Yeovil. 888 A

RATE FIXER and PLANNER REQUIRED by London Firm of Mechanical Engineers. General experience Non-repetition Work necessary.—Address, 892, The Engineer Office. 892 A

SALES ENGINEER, with Good Knowledge of Centrifugal Pumps, WANTED to Take Charge of Branch Office ; good progressive position. State age, experience and salary required.—Address, 937, The Engineer Office. 937 A

SENIOR ENGINEER WANTED by Large Manufacturing concern in the Manchester district, with first-class experience of Industrial Control Gear. The position offers a good opening to a man with the requisite training and ability, and there are good prospects for promotion.—Address, stating age, experience, and salary required, 911, The Engineer Office. 911 A

SOUTH AFRICA AND INDIA.—Well-known Continental ENGINEERING WORKS REQUIRE the SERVICES of TWO qualified ENGINEERS, one for South Africa and one for India. Applications are invited from gentlemen who have resided at least five years in either country and held responsible positions in the engineering world. A good sales record is essential, as the position involves the general management of the agency and calls for selling capacity rather than highly specialised knowledge in any particular branch of engineering. Applicants should state nationality, age, married or single, salary last earned and should submit a record of previous appointments. A thorough knowledge of English is essential, but nationality is otherwise unimportant.—Write, Box 605, c/o Judds, 47, Gresham-st., E.C. 2. 895 A

STOREKEEPER for Small Engineering Works REQUIRED. State age, experience, and salary required.—Address, 839, The Engineer Office. 839 A

THE DIRECTORS of a Well-known and Old-established FIRM of PUMP MANUFACTURERS, having carried out works extensions for manufacture of Turbine Pumps, INVITE APPLICATIONS for POST of DESIGNING ENGINEER ; proposals will be considered only from persons who have held similar posts and are well equipped with the necessary technical and practical experience required for the design and economical production of this class of apparatus.
Please state age and salary required.
Applications to be endorsed "Centrifugal" and addressed 776, The Engineer Office.
Foreign publications please note. 776 A

SITUATIONS OPEN (continued)

WORKS MANAGER for Welded Tube Works REQUIRED. Must be thoroughly experienced and first-class organiser.—Address, with full particulars as to age, experience, and salary, 905, The Engineer Office. 905 A

WANTED, JIG and TOOL DRAUGHTSMAN, with knowledge of Machine Design. State age, experience, and salary required.—Address, 920, The Engineer Office. 920 A

WANTED, JUNIOR DRAUGHTSMAN, Experienced in Chemical Engineering, with sound theoretical and practical training. Prospects of advancement to suitable candidate. State salary required and usual particulars of experience, &c.—Address, 923, The Engineer Office. 923 A

WANTED AT ONCE, 1st Class MECHANICAL and STRUCTURAL ENGINEERING DRAUGHTSMAN, neat and accurate, with knowledge of estimating and designing and with experience in Chemical or similar Plant Lay-out.
State age, experience, and salary required, also when at liberty.
Address, 935, The Engineer Office. 935 A

WANTED, Thoroughly Capable DRAUGHTSMAN for old-established business in the Midlands manufacturing special high-class machines. Must have had practical shop experience with machine tools and experience in staff management. Age about 35. Good prospects.—Apply by letter only, giving age, full details of experience, and salary required, to "ENGINEER," c/o Wykes and Co., Chartered Accountants, Leicester. P5447 A

CHIEF DRAUGHTSMAN REQUIRED by Firm in S.E. London district engaged mainly on Radio and Allied Apparatus. Only men with previous experience in running a drawing-office and who are masters of their trade need apply.—Address, giving full particulars as to experience and salary required, P5389, The Engineer Office. P5389 A

DETAILING DRAUGHTSMAN REQUIRED for Constructional Steel Works in North London. Must be able to prepare shop drawings with minimum supervision and be familiar with Steel Frame (1909) Act Buildings.—Address, stating age, experience, and salary required, P5473, The Engineer Office. P5473 A

DESIGNERS, with Experience in the Design of the latest type Heavy Motor Vehicle Chassis and Details, REQUIRED by a large firm in the South of England. Good positions to the right men.—Apply by letter, giving full particulars of experience, age, and salary required, &c., 750, The Engineer Office. 750 A

DRAUGHTSMAN, About 30 Years, with Good Mechanical Experience. Also JUNIOR, used to Boiler Details. Give full particulars.—Address, 939, The Engineer Office. 939 A

DRAUGHTSMAN, Mechanical or Electrical. Experience of Transformer or Electric Control Gear work an advantage.—Address, giving particulars of experience, age, and salary required, 831, The Engineer Office. 831 A

DRAUGHTSMAN (Not Junior) for Pumping Machinery, Reciprocating and/or Centrifugal.—Address, stating age, experience, salary required, 857, The Engineer Office. 857 A

DRAUGHTSMAN for Heavy Oil Engines, Land Type.—Address full particulars, age, and salary required, 858, The Engineer Office. 858 A

DRAUGHTSMAN, Senior, with First-class Experience of Power Transformers.—Apply, stating age, experience, and salary required, to MANAGER, Drawing-offices, B.T.H. Co., Ltd., Rugby. 819 A

DRAUGHTSMEN, STRUCTURAL and MECHANICAL, first class, REQUIRED in London district ; must be fully experienced in Material-handling Plant Contracts.—Write, stating experience, age, and salary required, to Box 299, Sells' Advertising Offices, Fleet-street, E.C. 4. 896 A

JUNIOR DRAUGHTSMAN REQUIRED, Country district (Gloucestershire) ; one used to Conveying Machinery an advantage, but not essential. Must be quick and accurate. State age, wage, and experience.—Address, 894, The Engineer Office. 894 A

REQUIRED, SEVERAL First-class DRAUGHTSMEN, with Aeronautical experience ; also TWO or THREE First-class MECHANICAL MEN. Good salary and overtime pay to suitable applicants. Give concise details of experience, salary required, &c., and when at liberty, to Messrs. THE BLACKBURN AEROPLANE and MOTOR CO., Ltd., Brough, E. Yorks. 752 A

REQUIRED for Important English-owned Railway in Argentina, DRAUGHTSMAN, experienced in Railway Carriage and Wagon Work. Commencing salary on 3 years' agreement £350 p.a., free passage.—Write, stating if single or married, age, education, training and experience, with copies (only) of testimonials, to Box B.P.E., c/o Davies, 95, Bishopsgate, London, E.C. 2. 930 A

JUNIOR DRAUGHTSMAN REQUIRED by a Firm of Constructional Engineers in London.—Address, stating age, experience, and salary required, P5472, The Engineer Office. P5472 A

TWO First-class JIG and TOOL DRAUGHTSMEN REQUIRED.—Apply, stating age, experience, and salary required, to the BRISTOL AEROPLANE CO., Ltd., Aero Engine Dept., Filton House, Bristol. 900 A

TWO JUNIOR DRAUGHTSMEN REQUIRED, with General Mechanical and Structural Knowlege, for large works in the Midlands. ALSO a JUNIOR, with experience in Conveyors and Elevators. Applicants must state age, experience, salary required and when at liberty.—Address, 921, The Engineer Office. 921 A

WELL-KNOWN COMPANY REQUIRES First-class DESIGNER for 50-100 H.P. 8-cylinder Engines.—Address, stating experience, &c., P5488, The Engineer Office. P5488 A

SITUATIONS OPEN (continued)

WANTED, First-class MILLWRIGHT FOREMAN, with experience in the erection of Rolling Mills or like machinery preferred.—Only really good men need apply, stating particulars, experience and salary required, to the D. and H. MANUFACTURING CO., Chaul End, Luton. P5471 A

FOREMAN REQUIRED for Machine Shops by Large Engineering Firm in the Midlands. Applications will only be considered from persons with extensive Machine Shop experience, capable of control, and good management. State age, firms worked for, class of machines.—Address, 845, The Engineer Office. 845 A

SITUATIONS WANTED

AS REPRESENTATIVE, Home or Abroad, for Constructional Steel Work Firm ; 20 years' technical and commercial experience. Highest credentials and references.—Address, P5464, The Engineer Office. P5464 B

CONTRACT Terminating Abroad. ENGINEER (41) REQUIRES POST. Experienced mech., constructional, contractors, railway works, comm. works, and dept. management.—Address, P5373, The Engineer Office. P5373 B

ENGINEER (40), Married, 1st Class B.O.T. Certificate, 4 years chief, many years' practical experience, machinery, boilers, electricity, sound knowledge refrigeration, internal combustion, SEEKS POSITION of RESPONSIBILITY.—Address, P5483, The Engineer Office. P5483 B

ENGINEER (29) SEEKS RESPONSIBLE POSITION ; public school education, experienced D.O. and assistant engineer, works extensions and maintenance.—BM/L024, London, W.C. 1. P5449 B

FULLY Qualified ELECTRICAL and MECHANICAL ENGINEER, 16 years' comprehensive experience, with knowledge of languages, commercial management and secretarial practice, SEEKS POSITION as Supervising and Maintenance Engineer with industrial concern.—Address, P5463, The Engineer Office. P5463 B

GENERAL WORKS MANAGER, M.I. Mech. E., DESIRES CHANGE ; successfully controlling engineering works, steel and ironfoundries, constructional and electrical work. He has had exceptionally broad experience, covering administration, organisation, commercial, technical and practical, up-to-date modern production and cost methods, both repetition and non-repetition, and big enough to take sole responsibility and produce dividend-paying results.—Address, P5477, The Engineer Office. P5477 B

G.I. MECH. E. (Age 23), 2 Years Shops, 5 Years D.O., SEEKS responsible progressive POSITION as Assistant Engineer, Kent, energetic and accustomed to responsibility.—Address, P5439, The Engineer Office. P5439 B

HEATING and SANITARY ENGINEER, M.I. H.V.E., M. Amer. Soc. H. and V.E., M.E. San. I., with wide experience at home and abroad, SEEKS RESPONSIBLE POSITION, either abroad or in this country. Thoroughly experienced in the designing of and estimating for modern systems of heating, hot and cold water supplies and sanitation. Manager for many years and used to taking full control and organisation of staff and workmen. Representation of first-class firm of manufacturers of heating or sanitary appliances considered. Excellent references.—Address, in strictest confidence, P5475, The Engineer Office. P5475 B

INDIA.—MECHANICAL ENGINEER, A.M.I. Mech. E., M.I.E. (India), age 41, fourteen years' Indian experience, ten years general manager large works, founders, ship repairers, structural and general engineers, carrying well-known agencies, good organiser, large business experience, consulted by public bodies on important engineering matters, director of several limited companies, good reasons for resigning last appointment, OPEN to ENGAGEMENT.—Address, P5479, The Engineer Office. P5479 B

MAINTENANCE ENGINEER (39), with a Number of years' experience in the control and maintenance of steam plant, dyeing, bleaching, chemical and general process machinery, drying plant, &c., experience of design and manufacture of special process machines, REQUIRES POST.—Address, P5465, The Engineer Office. P5465 B

MECHANICAL ENGINEER (30), Public School, full practical and commercial experience, REQUIRES responsible POST very urgently in works or commercial concern. London area preferred. No reasonable offer refused. Excellent references.—Write, Box W. 358, Willing's, 86, Strand, W.C. 2. 791 B

MECH. ENG. (26) SEEKS POS. as Assist. Engineer ; 5 yrs. app. all depts. constructional firm, 2 yrs. D.O., 3 yrs.' experience abroad.—Address, P3478, The Engineer Office. P3478 B

REQUIRED POSITION as Chief Engineer to Large Concern. For the last 5 years has been chief engineer to one of the largest breweries in the country. Previous to this 6 years in charge of machine and fitting shop of 500 men. Extensive experience of steam raising, mechanical and electrical plants, mechanical transport, cold storage and building construction. Desires responsible position.—Address, P5482, The Engineer Office. P5482 B

SALES ENGINEER, Rhodesia, Arrive Bulawayo approx. April-May, apprentice to executive in works, 6 years sales, DISENGAGED.—Address, P5480, The Engineer Office. P5480 B

STEEL WORKS REPRESENTATIVE SEEKS POSITION as SALES MANAGER WITH FIRST-CLASS FIRM.
Wide connection with engineers, &c.; 7 years' practical, 8 years' sales experience with high-class firm.
Address, P5476, The Engineer Office. P5476 B

MECHANICAL DRAUGHTSMAN (33) DESIRES CHANGE, preferably London. Good education, thorough shop and technical training, 7 years D.O., experienced in mechanical engineering, pump and engine work. Excellent references.—Address, P5484, The Engineer Office. P5484 B

QUALIFIED ENGINEER, Well Educated, Full Shop training followed by theoretical course, just returned from abroad on completion of contract, DESIRES POSITION of RESPONSIBILITY. Has had many years' experience in mechanical, electrical engineering, heavy erection work abroad, design, construction and operation of extra high-pressure steam plants, electrification of mechanical plants and some commercial experience. Fluent German and French.—Address, P5431, The Engineer Office. P5431 B

WILL FIRM REQUIRING REPRESENTATION among the Engineers, Shipyards, &c., of North England and Scotland, by a well-known experienced Traveller of high standing, please communicate.—Address, P5462, The Engineer Office. P5462 B

WORKS MANAGER DESIRES POSITION ; Wide experience, first-class record as organiser and production expert, experienced in general, electrical and high-grade mass production.—Address, P5485, The Engineer Office. P5485 B

For continuation of Small Advertisements see page 4.

A Seven-Day Journal

The Holborn Explosions.

THE Government inquiry into the cause of the explosions which occurred in the Holborn district of London on December 20th was concluded on Tuesday. The Attorney-General remarked that it would appear to be desirable from the point of view of public safety if the gas companies would in future give notice of any leakages of gas which they might discover in the neighbourhood of any big subway or tube in which gas might collect. On behalf of the Gas Light and Coke Company it was submitted that the Post Office "tube" which runs beneath the streets affected by the explosions was left unventilated and was a trap for the accumulation of gas of any kind which might be free to collect in the tube until such time as it became actively dangerous. Even if the Commission found that there was coal gas in the tube it was suggested that its presence was not to be ascribed to any lack of care on the part of the gas company, but that the primary cause of the explosion was the absence of ventilation in the tube. Professor R. V. Wheeler, Director of the Safety in Mines Research Board's experimental stations, stated in his evidence that in his opinion the gas involved in the explosion was coal gas. The shattering effect produced by the explosion could not, he maintained, have been caused by a methane-air explosion and highly improbably by a petrol-air explosion. Professor W. A. Bone, on the contrary, disagreed with Professor Wheeler and submitted that it was not so impossible for the damage observed to have been produced by a methane-air explosion and not so highly improbable that it was caused by a petrol-air explosion that coal gas only must be held responsible for it.

H.M.S. Dorsetshire.

IN a Journal note in last week's issue we stated that the new 10,000-ton cruiser "Dorsetshire," launched at Portsmouth on January 29th, would be equipped with internal combustion engines for cruising purposes, in addition to her main steam turbine propelling machinery of 90,000 S.H.P. We now find that in company with others, we fell into a mistake in this matter and that no internal combustion engines for cruising purposes are to be provided. We gather that the weights and spaces allowed are insufficient to permit such engines to be installed. In this connection it is perhaps worth noting that the Germans, in their 6000-ton cruisers of the "Königsberg" class, have provided turbine machinery for a speed of 33 knots, and in addition internal combustion machinery for a cruising speed of 15 to 16 knots. These cruisers carry a heavy armament and are provided with good protection.

Sir J. Alfred Ewing.

IT is officially announced that Sir James Alfred Ewing has intimated to the Court of Edinburgh University his intention to retire on September 30th from the Principalship of the University. Sir Alfred is in his seventy-fourth year and has been Principal of Edinburgh University since 1916, in which year he was appointed to succeed the late Sir William Turner. He received his academic education at Edinburgh University. From 1878 to 1883 he was Professor of Mechanical Engineering at the University of Tokio, and from 1883 to 1890 filled a similar post at University College, Dundee. From 1890 to 1903 he was Professor of Mechanism and Applied Mechanics at the University of Cambridge, and from 1903 until his appointment to Edinburgh in 1916 he was Director of Naval Education at the Admiralty. The present position of the Cambridge Engineering School is largely the outcome of Sir Alfred's work, while during his Principalship Edinburgh University has undergone an unexampled period of development which has included the founding of thirteen new chairs. While still at the Admiralty, and indeed for a year after his appointment to Edinburgh, he performed very notable service as the creator and head of an organisation for the interception and deciphering of enemy wireless messages. He is a Fellow of the Royal Society, a member of the Institutions of Civil and Mechanical Engineers, and a member of the Iron and Steel Institute. His textbooks on engineering, particularly his treatise on heat engines, are familiar to most engineering students, and are distinguished by their remarkable clearness of exposition and language. Last year he delivered a memorable James Forrest lecture entitled "A Century of Inventions."

The North-East Coast Exhibition.

PREPARATIONS for the North-East Coast Exhibition of Industry, Science and Art, which will be opened at Newcastle-upon-Tyne in May and which will be continued until October, are now well in hand, and some idea of the extensive nature of the Exhibition scheme can be obtained. The site chosen is on the south-western side of the Newcastle Town Moor, which is an open space of about 1200 acres adjoining the Great North Road and only about one mile from Newcastle Central Station. The main buildings were begun early last year and they include a Palace of Engineering and a Palace of Industries, each of which is about 420ft. long with a width of 240ft. These buildings face a grand court, and in communication with them is the Festival Hall. There is a Palace of Arts building a little distance away from the two main buildings above referred to, and the grounds are suitably laid out, with provision for outside exhibits. There will be representative exhibits from practically all the engineering and industrial undertakings in the North-East Coast area, and the London and North-Eastern Railway Company is to show replicas of some of its rolling stock and plant. An exhibit of scientific interest will be an unusually large telescope with a length of 25ft., which is being constructed by a Tyneside firm for Edinburgh University. The joint local patrons are the Duke of Northumberland and the Marquess of Londonderry, together with Sir Hugh Bell, Bt., while Sir Charles Parsons is the President. During the summer several important conferences will be held at the Exhibition. They include, besides others, the annual meetings of the Baltic and International Maritime Conferences, the Royal Sanitary Institute, the North-East Coast Institution of Engineers and Shipbuilders, and the Iron and Steel Institute. The general manager of the Exhibition is Mr. C. P. Hainsworth, with offices at Pearl Buildings, Northumberland-street, Newcastle-upon-Tyne.

Electric Lines Across the South Downs.

IN its annual report for the year ending December 31st, 1928, the Society of Sussex Downsmen reports that careful consideration has been given to the proposals of the Central Electricity Board to carry overhead cables along the Downs. The Society's immediate concern is with the Board's desire to carry a main transmission cable from Fishgate to Eastbourne diagonally across the Downs on 80ft. steel lattice masts, and from Fishgate to a place near Offham, where it will descend and proceed along the Weald. The Society has been in communication with the Board by deputation and correspondence, and it is understood that the technical reasons which prevent the use of underground cables are insuperable and an overhead line over the Downs is apparently inevitable. The Society has, however, proposed a shorter crossing *viâ* Mill Oak Valley and Edburton Bostel and then eastward along the Weald. But the Electricity Board has objected to this plan on the ground of additional cost. Having regard to the national importance of the preservation of the amenities of the Downs and the comparatively small additional sum needed in relation to the expenditure by the Board the Society is of opinion that the alternative proposal has not received adequate consideration. The Society has noted that, as a result of well-directed opposition, the original route for this cable, which involved crossing the entire length of the Downs from Fishgate to Eastbourne, has been modified to avoid the Downs entirely east of the river Ouse, and it sees no reason why a similar result should not be achieved in respect of the area west of the Ouse. To this end a communication setting forth the Society's proposals and suggesting joint action by all the local governing authorities in the area affected has been addressed to the authorities concerned.

An Industrial Delegation to Russia.

ON Tuesday, at a meeting in London which was supported by many leading firms in the engineering and other industries, it was resolved "to take immediate action to institute a representative delegation to proceed to Russia not later than March 8th." Last year the Soviet Government intimated that it would welcome a delegation representative of British industry and finance to examine the country's general economic situation, to consider a large number of constructive enterprises, and to discuss acceptable bases of finance. A list of enterprises considered necessary for the economic development of Russia over a number of years was prepared by the Soviet Department of Public Works and placed the total capital expenditure required at £460,000,000. This invitation was construed as one to British industry and finance to take a lead in the economic rehabilitation of Russia, and from it there arose the meeting last Tuesday organised by the Anglo-Russian Committee. That Committee has its headquarters at 4, Dean's-yard, Westminster, and its secretary is Mr. Victor Jones.

Wireless Pictures from America.

A FEW days ago the Marconi Wireless Telegraph Company gave a demonstration at the Somerton beam receiving station of its new system of facsimile transmission. In a darkened chamber visitors watched the reproduction of pictures and messages transmitted from the other side of the Atlantic. The speed of transmission is governed largely by atmospheric conditions, which at the time of the demonstration were not particularly good. An image measuring 8in. by 10in. has been transmitted from Rocky Point and received at Somerton in 3½ minutes, but in some cases the time required for the reception of the same picture transmitted over the same distance has been nearly twenty minutes. A picture of the Woolworth Building, cartoons, and a message in the handwriting of the sender were among the images received during the demonstration, and the rapidity and accuracy with which they were reproduced showed the advance that has been made in this branch of wireless telegraphy. Although up to the present the experimental transmissions to Somerton have been made from America, it is intended to lay land lines and to put, for example, London and New York into direct communication for transmitting and receiving messages and pictures. It is suggested that in time a facsimile service may replace Morse telegraphy on busy circuits and that the receipt of telegrams in the actual handwriting of the sender may become the normal procedure, but at present there is no indication of when the new system will become available to the public.

National Flying Services, Ltd.

A COMPANY, known as National Flying Services, Ltd., has recently been formed, with a capital of £500,000, to encourage the development of civilian flying in this country. At the outset it is intended to establish twenty-three air parks, each equipped with aircraft, sheds, workshops, &c., and at least a hundred landing grounds provided with service facilities. A hundred aeroplanes will be put into service to begin with for flying tuition, private hire and other kinds of commercial work, and fifty flying instructors will be employed. It is the company's ambition to place every house in England within 15 miles of an aerodrome and to secure that no flier shall ever be more than a few minutes' flight from a landing place. The central air park will be at Feltham, near London, and will have twelve light aeroplanes attached to it. At the provincial air parks flying clubs will be formed. The managing director of the company is Lt.-Col. I. A. E. Edwards, recently Technical Advisor, Directorate of Civil Aviation, Air Ministry, and with him are associated on the board Capt. F. E. Guest, the Master of Sempill, Sir Alan Cobham, and Mr. J. G. Peel. It is officially announced that the Air Ministry is entering into an agreement with the company under which Government grants will be paid to the company over a period of ten years. The grants are to be paid with respect to the number of club members who qualify for their pilot's licence. The grants will be paid at the rate of £10 per qualifying member per year for the first three years and £5 per year for the next seven years. The agreement stipulates that within three years the company shall provide and maintain twenty new aerodromes and eighty new landing grounds in this country. Speaking in the House of Commons on Wednesday last, Sir Samuel Hoare, Secretary of State for Air, referred at length to this scheme. He said that he was satisfied that there was at the present time a large and growing demand for the development of flying. The advantages possessed by the scheme, such as the provision of a large reserve of pilots and the creation of a chain of aerodromes and landing grounds, could not possibly be secured otherwise than through the medium of a commercial organisation without a much larger expenditure from the Air Votes than was entailed by the proposed grants.

The Stability of Ships.

THE report of a special committee appointed by the American Marine Standards Committee to consider the question of the stability and loading of ships has now been approved by the Council of that body. Discussing this report, Mr. David Arnott, the Chief Surveyor of the American Bureau of Shipping, has pointed out that the principal modification to the original draft proposed lies in the reduction of the standard metacentric height for the light ship condition from 15in. to 6in. in the case of single-bottom ships and from 9in. to neutral in the case of vessels which have double bottoms. In addition there is an amendment to the wind heel formula which has the result that all vessels except those of the largest ocean-going types have smaller metacentric heights than those formerly required. The report represents what is believed to be the first attempt to lay down regulations for stability. There is a considerable body of opinion which regards the subject of stability unsuited for a marine standard, and prefers to leave the matter of stability with the master of the ship. Mr. Arnott considers, however, that stability is too important a matter to be left entirely to the judgment of the captain, as it is in the British Load Line Committee's rules and in the United States Load Line Committee's report of 1921. While not desiring to relieve a captain of the responsibility for safe loading, Mr. Arnott feels that the owner of a ship is entitled to receive from the builders a vessel with a sufficient margin of stability. In America the position is different from that in other maritime countries, and since 1924 shipbuilders and owners have been called upon to incline all new passenger ships under the supervision of the Steamboat Inspection Service. Some cases have occurred in which, after considerable controversy, permanent ballast has had to be installed, and Mr. Arnott is of the opinion that there cannot be active Government jurisdiction over the stability of passenger ships without some definite standard.

Automatic Weighing Machines.

No. III. (*conclusion*).*

MECHANICALLY FED WEIGHER FOR SLUGGISH MATERIALS.

IN Figs. 13 and 15 we illustrate a "Reform" automatic weigher fitted with a mechanical feed in order to adapt it to the weighing of offal or other material which flows sluggishly. From what we have said previously regarding the necessity for compensating an automatic weighing machine it will be realised that any variation in the rate of flow or continuity of the dribble feed would upset the accuracy with which the compensating device performs its work. If the dribble feed varies, there will be a variation from batch to batch in the amount and momentum of the material in transit during the period between the movement of the beam through the horizontal position and the closing of the feed gates. Consequently, no one setting of the compensating weight will prove effective.

In the design of a mechanical feed to ensure continuity and constant flow of the material through the gates, care has to be taken that the device will handle the material gently, for attrition would, in most cases, be a serious objection to the use of the weigher. In the design evolved by Henry Simon, Ltd., the material enters the hopper A, Fig. 15, and is carried over the feeding aperture B by wipers C which are designed to give a gentle motion to the material. The wipers are driven through worm gearing contained inside a dust-proof compartment. The rest of the machine embodies the same general principles as those employed in the standard "Reform" design already described. The details are, however, modified somewhat. The feed gate D is pivoted at E. It has a large radius and works very close to the wipers. The usual hopper neck is dispensed with and in its place the feeding aperture is shrouded by walls composed of brushes. As a result, arching and packing of the material cannot take place.

The falling arm F has an extension G which bears against a roller H on the gate closing lever J. The gate-supporting arm is counterweighted at K to maintain it in contact with a second roller L on the gate closing lever. The falling arm is lifted by a round-nosed pin on the beam and raises the gate closing lever by pressure on the roller H, thereby allowing the gate to open under the action of the weight K. On the descent of the beam the gate gradually closes until the end of the falling arm makes contact with a trip trigger in the usual way. The dribble feed now takes place through the partially closed hopper aperture. The sluggish flow of the material, it will be noted, renders it unnecessary to employ a separate dribble gate and aperture. When the beam passes through the horizontal position it knocks out the trip trigger and allows the falling arm to descend, whereupon the gate closing lever, deprived of its support at H, closes the feed gate smartly by pressure through the roller L.

The end of the falling arm when it descends knocks out the lever M and the pressure of the material inside the bucket opens the door and pulls round the quadrant N. A roller on this quadrant makes contact with the pendulous lever P and pushes it over to the right. As a consequence, the curved end Q of a locking lever is moved over a roller R at the end of an extension lever S attached to one of the gate-supporting arms. The gate is in this way locked while the bucket door is open. The closing of the bucket door allows the pendulous lever P to withdraw the locking lever Q from the path of the roller R. The lever S is now again free to rise and the feed gate to open. The engraving illustrates the machine in the testing position with the falling arm supported short of its lowest position by the engagement of a pin with the quadrant T. As the falling arm has not in this position struck the lever M, the bucket door does not open, and because the bucket door has not opened the lever Q fails to lock the feed gate in the closed position. To secure such locking action in the testing position an auxiliary catch U is provided to engage above the roller R. In normal operation the roller pushes the auxiliary catch aside, when the lever S rises on the opening of the feed gate.

PORTABLE NET SACK WEIGHER.

Another variation of the standard "Reform" design is the portable net sack weigher illustrated in Figs. 14 and 16. The outstanding feature of this machine is the fact that it is designed to provide a hand control for the discharging of the bucket contents into the sack placed ready to receive them. It is capable, we are informed, of dealing with 240 to 280 sacks an hour, the actual capacity being

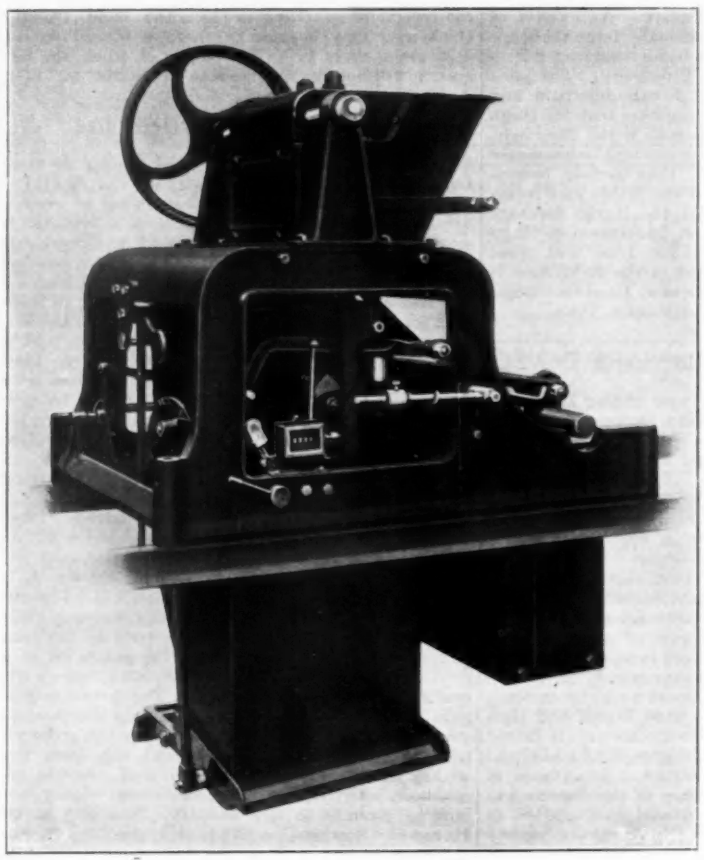


FIG. 13—"REFORM" AUTOMATIC WEIGHER WITH MECHANICAL FEED

FIG. 14—PORTABLE NET SACK WEIGHER

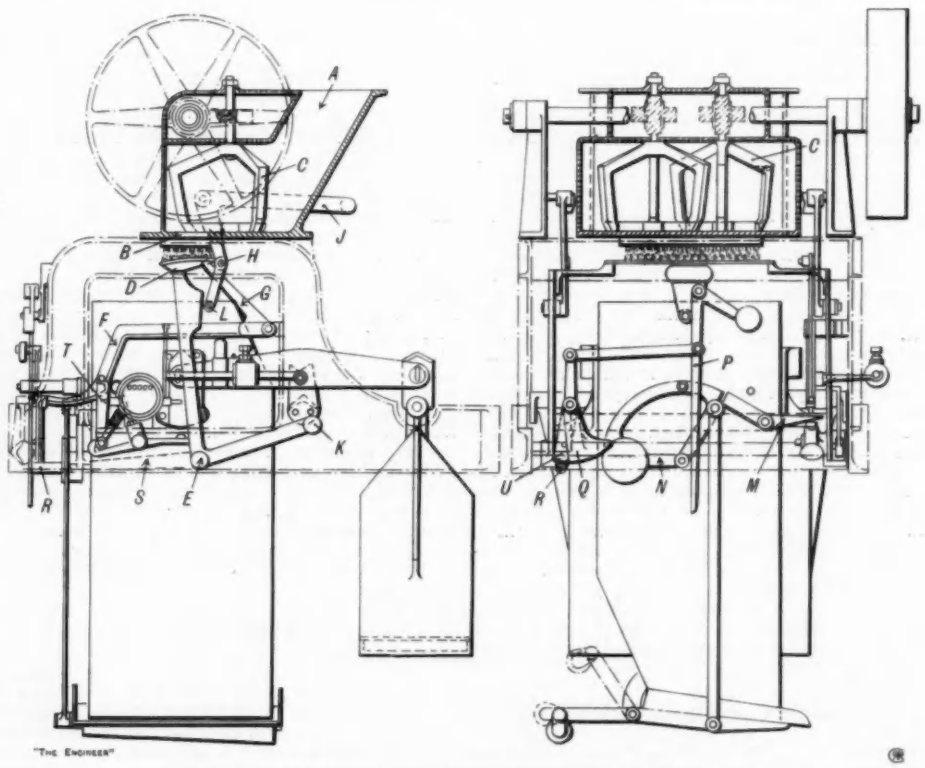


FIG. 15—AUTOMATIC WEIGHER WITH MECHANICAL FEED

* No. II. appeared February 1st.

dependent upon the ability of the operator to remove the full sacks and replace them by empty sacks. The high speed of operation is made possible by the fact that the machine is designed to perform the weighing operation while the sacks are being changed. As soon as an empty sack is in position a touch on a releasing lever discharges a completed weighment into it, and as soon as the bucket is empty the machine auto-

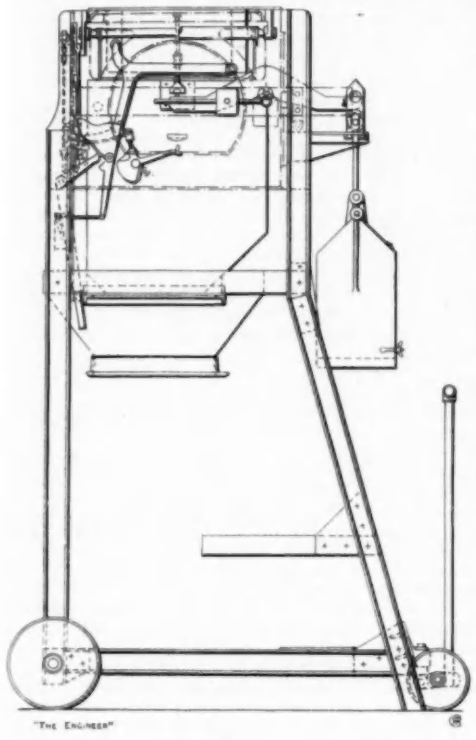


FIG. 16 PORTABLE NET SACK WEIGHER

matically begins the next weighment ready for the next release.

From Fig. 16 it will be seen that the main elements of the machine follow the standard "Reform" principle, the chief subsidiary difference being that the feed gate axis is at right angles to, instead of parallel with, the axis of the beam knife edges. The principal additional feature is the means provided for the hand release of the weighment. This mechanism is so designed that it is impossible to move the releasing handle until a weighment has been completed. At the same time it is such that the actual pressure applied to the handle does not affect the accuracy of the weighing.

The release details are shown on an enlarged scale in Fig. 17. When the beam passes through the horizontal position and knocks out the trip trigger the falling arm descends far enough to close the feed gates, but not far enough to knock out the bucket door lock. It is retained in this intermediate position by a pin on its face making contact with an intercepting quadrant in the same manner as, in the normal machine, the full descent of the falling arm is checked by a quadrant when it is desired to test the accuracy of a weighment. The intercepting quadrant in this case is, however, made heavy on one side—on the side giving it a tendency to withdraw it from beneath the pin on the falling arm. It is retained in the intercepting position by a strut A united to an operating handle B which is counterweighted to keep it in the full-line position indicated in Fig. 17. To release the weighment the operator pulls the handle B towards him. The nose of the strut A is thereby lowered opposite a bight near the root of the intercepting quadrant, and that quadrant becomes free to move away from beneath the pin on the falling arm, the movement, if necessary, being assisted by pressure from the strut A on a lug projecting from the edge of the quadrant. The completion of the descent of the falling arm opens the bucket door in the usual way and results in the discharge of the contents into the sack.

At the upper corner of the intercepting quadrant there is a portion of the edge which is struck with a radius from the axis about which the falling arm swings. At the end of the falling arm there is a pin D which makes contact with this face. This pin is in the position marked 1 when the hopper gates are open for the full feed, and in the position 2 when the dribble feed is taking place. When the pin is in either of these positions—that is to say, while the weighment is still incomplete—it supports the quadrant, so that even if the handle B is operated the quadrant will not move and consequently the bucket contents will not be discharged. When the weighment is completed and the falling arm descends until intercepted by the quadrant, the pin D assumes the position 3. In this position it allows the quadrant to be moved. On the completion of the descent of the falling arm, the pin D takes up the position 4. When the discharge of the bucket is completed, and the falling arm rises, the pin 4 lifts the quadrant and restores it to the intercepting position, where it is retained by the rising of the strut A once more into the full-line position.

It will be seen that the counter E is directly connected to a tail piece on the quadrant. The weighment is therefore not recorded until it is actually discharged from the bucket, and, consequently, no confusion can arise.

The unit as a whole is mounted on a steel frame provided with roller bearing runners. The wheeling and steering are controlled by an arrangement, which is such that the action of moving the handle into the wheeling position lifts the legs from the floor and transfers the weight to the four runners. When the handle is lowered the legs give the machine a rigid support.

AUTOMATIC BLENDING CONTROL.

It is frequently required to mix two or more different materials or different qualities of one material in a given weight ratio. For example, a blended flour may be derived from a wheat mixture consisting by weight of 30 per cent. No. 1 Manitoba, 10 per cent. No. 2 Manitoba, 20 per cent. Australian, 15 per cent. Plate, 15 per cent. Blue Stem, and 10 per cent. English wheat. It is clear that it is wrong in principle and must be inaccurate in practice to attempt to achieve such a blend by mixing the different wheats on a *volume* basis or by endeavouring to regulate each of the six flows to the correct rate required to give the desired mixture. Since the mixture is specified on a *weight* basis, the batches of the separate wheats composing it must be measured by weight. If each wheat is weighed in a separate machine entirely unconnected with the other weighing machines of the battery the proportioning may be unreliable, for the stoppage of any of the weighers or the exhaustion of any one of the sources of supply would affect the proportions of the mixture, possibly with serious results. In the "Reform" automatic blending control system, the principle adopted is such as to prevent any weigher of the battery from discharging until all the weighers have completed their weighments and

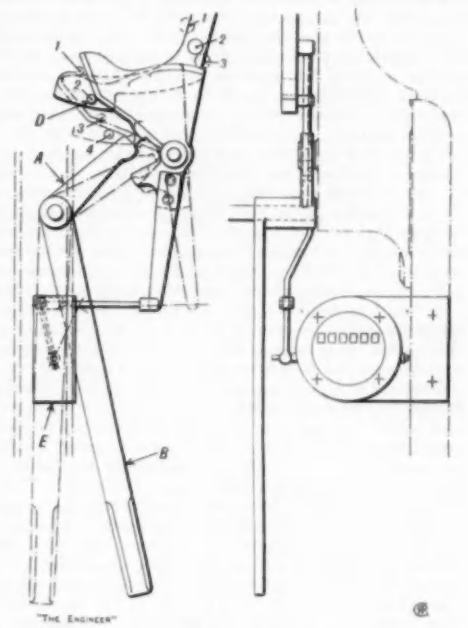


FIG. 17—RELEASING MECHANISM OF SACK WEIGHER

are ready to discharge. It is further arranged that none of the weighers shall start on the succeeding weighment until the preceding weighments have been cleared from all the machines in the battery.

In the case of the wheat mixture referred to above, six weighers would be employed. These machines would be set to deliver at each weighment, 90 lb., 30 lb., 60 lb., 45 lb., 45 lb., and 30 lb., giving a total for the battery of 300 lb. per discharge. At 400 lb. of wheat per 280 lb. sack of flour, the weighers, in the case of a mill having a capacity of forty-five sacks an hour, would be set to discharge sixty times an hour.

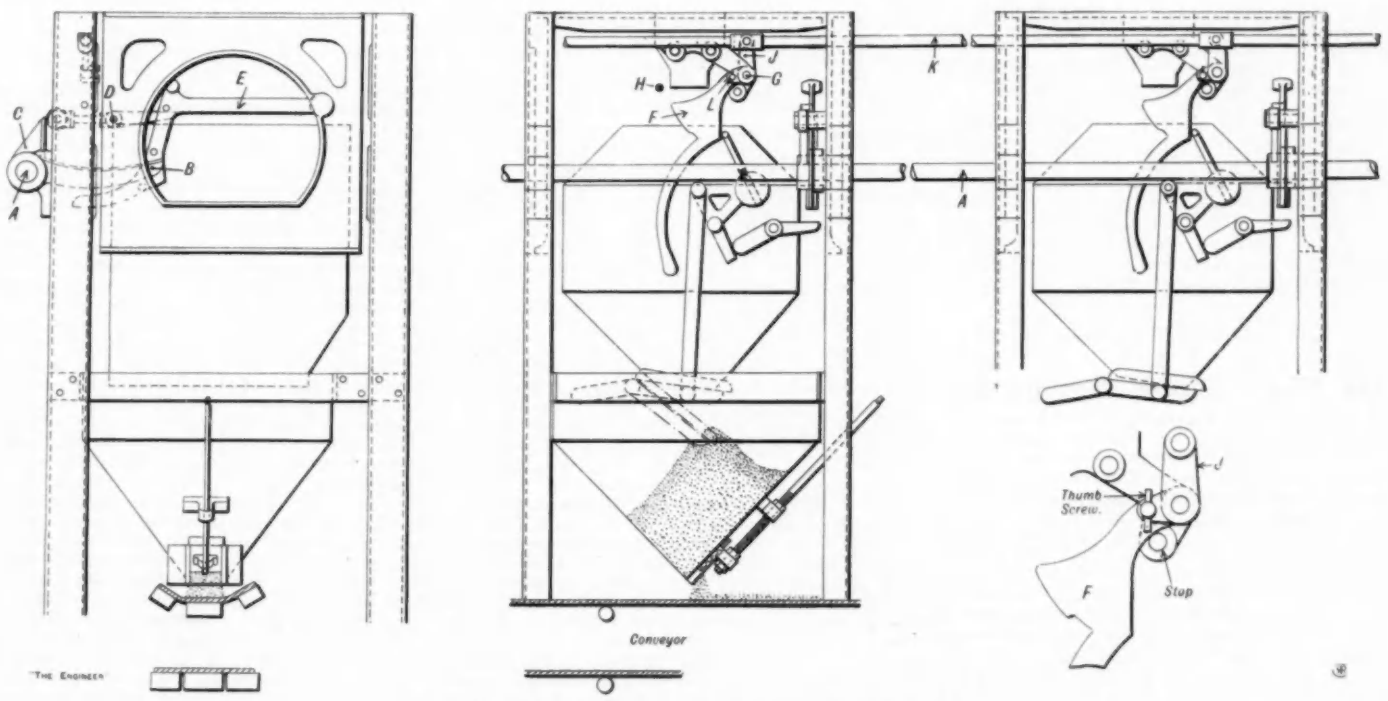


FIG. 18—"REFORM" AUTOMATIC BLENDING EQUIPMENT

The method of interconnecting the machines of a battery is illustrated in Fig. 18. Each weigher, it will be gathered, discharges the contents of its bucket into a bottom hopper, whence the wheat flows on to a conveyor serving the whole of the battery. All the machines of the battery are connected by a shaft A. This shaft carries a series of lever arms B, one for each machine. The weight of these arms tends to turn the shaft A in the clockwise direction, as seen in the end view in Fig. 18. Rotation of the shaft is, however, prevented by a second series of levers C,

one for each machine, the ends of which abut against rollers on a corresponding series of catches pivoted at D to the frames of the machines. When the falling arm E of any one of the machines descends on the completion of the weighment for which that machine is responsible, a pin on its side knocks out the catch. The falling arm descends a little further until a second pin on its side makes contact with the arm B. The descent thus permitted to the falling arm is not sufficient to bring about the opening of the bucket door. One after another the arms C are relieved of their roller abutment, until only one—that of the slowest working machine—remains in position. When that machine completes its weighment the knocking out of its catch removes the last restraint on the shaft A. That shaft thereupon turns and deprives all the falling arms simultaneously of the support of the arms B. The falling arms therefore complete their descent, and all the bucket doors open simultaneously to discharge the weighments into the lower hoppers. On the rise of the buckets a third pin on each of the falling arms engages with the underside of each of the arms B and restores the shaft A and the catches to the position shown in the engraving. Should it be desired to run the battery with one of the machines out of action, the catch of that machine is disengaged from its arm C in order that the idle machine may not hold up the discharge of those which are working.

When the falling arm completes its descent, it knocks out the bucket door catch in the usual way, the bucket door opens, the quadrant lever is pulled round and the pendulous lever F pivoted at G is swung to the left. An edge of the lever F is thereby brought against a pin H on the side of the feed gate, and locks that gate in the closed position. A bell crank lever J also pivoted at G is connected by one of its arms to a shaft K running along the battery. Its other arm is connected by a thumbscrew L to the pendulous lever F. With this thumbscrew in position the levers F and J move as if they were in one piece pivoted at G. Consequently, the rise of any one of the pendulous levers F not only locks its feed gate, but moves the shaft K to the right, thereby raising all the pendulous levers, and locking all the feed gates throughout the battery. In general, the tripping of the bucket doors occurs simultaneously, and consequently the action of any one is not solely relied upon to effect the locking of all the feed gates. Conditions are, however, otherwise when the time comes for the unlocking of the feed gates. Some of the buckets empty and rise earlier than the others. The closing of their doors does not, however, bring about the unlocking of the feed gates preparatory to the start of the next weighment in the usual way. So long as any grain, even a very small amount, remains on the bucket door of any of the machines, that door is prevented from closing Of necessity, therefore, the lever F of that machine cannot fall. Until it does fall, the shaft K cannot move to the left, and as a consequence none of the other feed gates can be unlocked. When the last bucket door closes, all the levers F fall simultaneously, all the feed gates are unlocked, and all the machines of the battery begin the succeeding weighment.

To regulate the number of weighments per hour in accordance with the requirements of the mill, it is clearly necessary to regulate only the speed of working of the slowest machine in the battery. This regulation may be effected either by controlling the extent to which the feed gate opens or by controlling the outlet from the bottom hopper. If it is desired to run the battery with one of the machines inoperative, the thumbscrew of that machine is withdrawn. The levers F and J then become separated, and the idleness of the machine is without effect on the freedom of movement of the shaft K.

The Bridge Stress Committee's Report.

IN March, 1923, the Committee of the Privy Council for Scientific and Industrial Research appointed a Committee, the Bridge Stress Committee, "to conduct researches with reference to the stresses in railway bridges, especially as regards the effects of moving loads." The Committee consisted of Sir J. A. Ewing (chairman); Mr. C. J. Brown, of the L.N.E.R.; Mr. A. C. Cookson, of the G.W.R.; Professor W. E. Dalby; Mr. G. Ellson, of the S.R.; Sir R. R. Gales, Professor C. E. Inglis, Col. Sir J. W. Pringle, Mr. R. V. Southwell and Mr. E. F. C. Trench, of the L.M.S.R. At a later date, when it was found that the problem was intimately connected with questions of locomotive design, Sir Henry Fowler was invited to join the Committee. The Committee secured Mr. Conrad Gribble, of the L.N.E.R., as its chief engineer, and Mr. T. H. Hopkins as assistant chief engineer. In addition, it had on its staff at one time or another sixteen junior assistant engineers and received assistance from certain members of the Cambridge University Engineering Laboratory staff.

The Committee's report was published on Friday, February 1st, and is obtainable from H.M. Stationery Office, price 18s. net. It runs to over two hundred large-sized pages and contains numerous diagrams, tables and appendices. In what follows we reproduce, from its earlier sections sufficient to enable our readers to form a just impression of its contents.

The wide terms of reference under which the Committee was appointed have to be intrepreted with due regard to the condition of engineering knowledge and practice prior to our appointment. For some years there had been much discussion among engineers of certain questions affecting bridge design, especially questions relating to the influence of moving loads. It had long been regarded as necessary to distinguish between static stresses, such as are due to the weight of the structure or to the presence of loads upon it, and dynamical stresses which may, in addition, arise through the passage of moving or "live" loads; and it had been customary to make, in one way or another, some allowance for what, in this connection, is comprehensively called "stress due to impact." A locomotive or train moving over a bridge produces by its mere presence a temporary increase in the static load on the bridge and the stresses in the members. This is a direct effect of its weight, and for any given position of the load it is the same whether the load be at rest or in motion. But over and above this, a travelling load also produces, in general, some stress due to the fact that it is moving or that there is relative motion of its parts. Any stress which a load causes by reason of its own motion or the motion of its parts is commonly called an "impact" effect. The name, though scarcely logical, is usual and convenient.

The extent to which impact effects occur, and the allowance that should be made for them in design have been matters of controversy. There has been no general agreement among engineers as to the causes and exact nature of the action, or as to the rules that should be followed in determining the dimensions of bridge members. Many formulas have been proposed for dealing with impact effects, but without sufficient support either in theory or in experiment. The subject has been discussed on more than one occasion by the Institution of Civil Engineers. The published papers and discussions contain many points of interest, and illustrate wide divergences in opinion and practice.

Recognising that the subject required further investigation, the American Railway Engineering and Maintenance of Way Association undertook an extensive series of experiments on railway bridges in the United States, the results of which were published in July, 1910. An independent inquiry was set on foot in India in 1917, by a Committee appointed by the Indian Railway Board, under the chairmanship of Mr. G. Richards, then Chief Engineer with the Board, and was continued for several years, with results which are set forth in a series of reports and other technical papers. In 1919 the (British) Railway Engineers' Association appointed a Committee to revise the loading table used in bridge design and to make suggestions regarding permissible stresses in both new and existing bridges and the allowance required for impact. A report of that Committee adopted by the Association in 1920, while suggesting certain rules, pointed out the necessity for systematic and careful experiments with the object of verifying the suitability of the Pencoyd formula, which it tentatively recommended with a view to avoidance of delay in obtaining uniformity of practice, then being urged by the Ministry of Transport.

About the same time a Committee of Railway Officers, selected by the companies, was appointed by the Minister of Transport under the chairmanship of the Chief Inspecting Officer of Railways, Colonel—now Sir John—Pringle, to assist in the revision of the "Board of Trade Requirements, 1914, in regard to the opening of railways." This Committee, being impressed with the absence of data and dissatisfied with the suitability of the Pencoyd formula as a means of treating impact effect, suggested that the Ministry of Transport should carry out further tests. This was done in the summer of 1920, with results which are published in a report entitled "Tests on Railway Bridges in Respect of Impact Effect," by Major—now Lieut.-Col.—A. H. L. Mount, of the Ministry of Transport. This report suggested certain modifications of the Pencoyd formula which it was at first proposed should be embodied in the revised "Railway Requirements." In the meantime the British Engineering Standards Association, late in 1920, appointed a committee under the chairmanship of Mr. C. J. Brown, then Engineer-in-Chief of the Great Northern Railway, to draw up a standard specification for girder bridges. That committee, while provisionally adopting and incorporating the formula proposed by the Ministry of Transport, with certain limits and allowances, decided that further experimental work was essential before final recommendations could be made regarding allowance for impact. The co-operation of the Department of Scientific and Industrial Research was invited, and after a conference with railway engineers and others had been held under its auspices in May, 1922, arrangements were made for prosecuting an inquiry, to be financed partly from public funds and partly by the railway companies, which also undertook to provide all necessary facilities for tests of bridges. The Bridge Stress Committee of the Department of Scientific and Industrial Research was accordingly appointed in March, 1923.

The foregoing references will have indicated that our immediate task was to elucidate the question of "impact" stress by examining its actual character and causes. These were felt to be somewhat obscure, notwithstanding all the attention the subject had already received. It appeared that further experimental inquiry was desirable, in which the tests should be directed to certain specific points. It was also clear that in selecting points for investigation, and in arranging methods and interpreting results, there should be a continuous association between experiment and scientific analysis.

Our researches have been confined to bridges of steel and wrought iron, in the form of horizontal girders resting on supports at the ends. We have not dealt with arches, whether of masonry, concrete, or metal, nor with continuous girder bridges. Our aim has been not only to clear up doubtful points regarding the nature and amount of the stresses to which railway bridges are subject and the conditions under which stresses may arise, but on the basis of such conclusions to formulate rules suitable for practical service in the design of new bridges or in the estimation of the margin of safety of old bridges under modern loads.

At an early stage of our inquiry we realised that no formula can be valid which treats the whole of the impact effect in a bridge of given span as being proportional to the live load. The Pencoyd formula is a familiar example of this class. Various other formulas of the same kind have been proposed, and some of them have been widely adopted in bridge design. Such formulas cannot claim rational justification as an expression of the impact effect, for there is no proportionality between that effect and the amount of the moving load on the bridge. In our opinion, any formula which allows for impact effect in this way should be discarded by designers. Besides being illogical in its basis it gives, in its application, wrong results.

It seems probable that the use of formulas which imply such a proportionality may have arisen from a somewhat irrelevant application of Wöhler's results regarding fatigue. A formula of the Pencoyd class has an effect not unlike that of a formula of the "range-of-stress" class. For what it does is to secure in short bridges, where the ratio of live load to dead load is comparatively great, a smaller working intensity of stress than in long bridges, where the load is more nearly constant; and a range-of-stress formula does this too. But whatever may be said for using a smaller working stress in short bridges than in long bridges, it is clear that the variation of stress which is produced by adding the (transient) live load to the (permanent) dead load is distinct from, and should not be confused with, those dynamical effects of live load which make up what is called impact. Any stress that is due to impact should be allowed for independently of considerations relating to fatigue.

There will remain, after impact has been fully allowed for, the separate question whether, in consequence of variation in the load, any provision should be made for possible fatigue. There is no reason to suppose that fatigue becomes operative under the conditions of stress which actually apply in bridges; and there appears to be no experience of failures in steel or wrought iron bridges traceable to this cause.

It may be that the very general adoption of the principle of employing a low working stress for small bridges and floor members and a greater stress for longer girders has arisen, not so much from considerations of possible fatigue, as from the idea that in girders which carry considerable load and are of great mass the effects of shocks due to moving loads are less severely felt than in light girders which carry little permanent load. Many railway administrations on the Continent have adopted rules whereby the permissible stress in girders varies with the span. Rules, however, which fail to discriminate between the impact effects of different classes of engines are open to objection, not only on account of their lack of reasonable foundation, but also because the allowances which they provide for impact are generally unsuitable.

At the same time it may be remarked that, in consequence of the use of formulas of the kind now criticised, bridges have often been designed in the past with a degree of strength generally excessive for the loads they had originally to bear. This excess of strength has often enabled them to take with impunity the large increase in the weights of locomotives and other rolling stock which has come about since they were built. Thus the type of formula here referred to has incidentally done a useful service in providing for a development of railway practice to which it had no intended relation. But it is open to the fundamental objection of ignoring the fact that it is not in the main the travelling load as such which produces impact effects. These effects are caused by variations in that load, the chief of which is due to hammer-blow. We omit, for the present, consideration of minor effects due to rail joints and other causes.

The idea of an impact factor greater than unity, by which the amount of the moving load should be multiplied in order to take account of impact effect, has no correspondence with the facts. In long bridges, where the effects of impact can be submitted to fairly

complete analysis, it leads to results which are obviously quite erroneous. In short bridges, for which the analysis is necessarily less complete, treatment must be more empirical and a rougher method of estimation has to be resorted to.

Some misconception has possibly arisen from the well-known dynamic effect of suddenly attaching a heavy mass to an elastic support. When a weight is hooked on to an otherwise unloaded spiral spring and let go, it is a familiar fact that the spring will stretch to a distance nearly double its static extension for the same load. Under such conditions the impact effect is proportional to the load, and it is found by using a multiplying factor of nearly 2. It may have been supposed that in the quick transit of a load across a railway bridge a more or less similar effect, involving a smaller multiplying factor, must be reckoned with; but, in fact, as the investigations of Professor Inglis have shown, no appreciable effect of this kind occurs in railway bridges. It would require the load to reach the middle of the bridge more quickly, and to pass off more slowly, than happens in any actual or possible transit. In the absence of hammer-blow, of rail joints and of any imperfections in rail and tire surfaces, so that the motion is one of perfectly smooth rolling, the dynamical effect produced by the passage of the load, at any practicable speed, is insignificant. The impact effects with which the engineer has to deal arise from the motion not being one of smooth rolling, and especially from the periodic variation of rail pressure that is due to hammer-blow.

These variations have no proportionality to the load; they may be far greater in a light locomotive than in a heavy one; in a three or four-cylinder locomotive they are relatively small, and in an electric locomotive they may be absent.

The problem before us included the following items:—

(1) To establish a relation between the pulsating forces which are exerted by a locomotive when travelling at speed, and the consequent oscillation and stresses in the bridge.

(2) To measure any stresses and deflections that are due to the dynamic action of moving loads, unconnected with the hammer-blow of locomotives.

(3) To express the probable impact effect on bridges in a form suitable for general use by designers, either by means of a formula or otherwise.

(4) To investigate the characteristics of locomotives, and the possibility of modifying their design with a view to reducing impact effects.

The field work proper has been designed to deal with problems (1) and (2), and in addition a large amount of experimental work has been carried out at locomotive centres with a view to ascertaining the actual magnitude of the hammer-blow.

SYNOPSIS OF THE REPORT.

The following synopsis briefly summarises the main features of the report:—

Instruments.—The selection and design of suitable instruments occupied much attention in the early stages. For measuring the strains in the individual members of a bridge the Committee relied mainly on two types of recording extensometer: the "Fereday Palmer," which records photographically on a moving film, and an instrument developed by the Cambridge Instrument Company, in which a stylus draws a miniature record on a moving strip of celluloid. Both these instruments, after various modifications had been made to adapt them for use under the difficult conditions which are met when a bridge is tested under the shock of a fast-running engine, gave fairly satisfactory results. Much of the experimental work has consisted in recording the oscillatory deflection, usually at the middle point of the span, which the girder undergoes during the passage of the load. For this purpose the Cambridge Instrument Company supplied a convenient and accurate recording deflectometer.

Checks on Accuracy.—In recording the effects of travelling loads it is difficult to escape errors which arise from dynamic features of the instrument itself, such, for instance, as may be due to the inertia of its own parts, causing in some cases a spurious or exaggerated response to an applied impulse. Careful study was required to eliminate trouble from this source, and many laboratory tests were made with the recording instruments in various conditions of periodic disturbance. Recourse was also had to an electrical method of magnifying very small displacements, in such a way as to escape effects of inertia. A strain recorder on these lines, the record of which was taken by means of an Einthoven galvanometer, was developed for the Committee's use by Mr. H. A. Thomas, and was the subject of further experiments by Mr. E. B. Moullin. This method was tested both in the laboratory and on various bridges. Although the Committee found the Thomas electrical device much less convenient for ordinary use in the field than the mechanical types of apparatus which were usually employed in its tests, the special investigations made with it by Mr. Moullin served a very useful purpose in showing how far the mechanical records were trustworthy, how they should be interpreted, and what features in them were to be ascribed to instrumental defects.

Relation of Strain in the Members to Deflection of the Girder.—Independent measurements of the strains in individual members of a girder and of the deflection of the girder as a whole confirmed the expectation that, as regards effects due to impact no less than those due to static loads, there is a close correspondence between the deflection and the stresses in what may be called the principal members, namely, those of the top and bottom booms. It therefore becomes possible to accept records of deflection as sufficient for many purposes without direct records of tensile and compressive strain. The members which bear the shearing force are dealt with separately.

Bridge Oscillator.—An apparatus called a bridge oscillator was constructed, by which vertical impulses of any desired frequency could be applied to any bridge. By its means the "hammer-blow" effect of a locomotive could be imitated, the conditions favouring oscillation could be more fully studied, and the influence of damping ascertained.

Tests on Bridges of Effects of Hammer-blow.—With the co-operation of the four chief railway companies, systematic tests have been carried out on fifty-two bridges of various types, with spans ranging from 16½ft. to 345ft. At an early stage it was realised that, except in very short bridges, the effects chiefly requiring study were those which came from an approximate synchronism between the hammer-blow of the locomotive and the natural period of oscillation of the bridge carrying the load. For the purpose of the tests the railway companies lent locomotives, some of which were selected as being particularly suitable on account of their exceptionally large unbalanced vertical forces. By running such engines at an unusually high speed the effect of large hammer-blows was studied, and by varying the speed through an extensive range a critical speed was found at which the effects of synchronism were most apparent. In certain cases two critical speeds were observed, and this threw a very important light on the whole problem.

Theoretical Investigations, Supplementing and Interpreting the Experiments.—Concurrently with the tests of bridges, Professor Inglis, a member of the Committee, undertook a theoretical investigation of bridge oscillations, the first part of which was communicated to the Institution of Civil Engineers in March, 1924. The theory there set forth proved to be of great service in contributing to guide the whole inquiry. More recently Professor Inglis has followed the matter up by a further paper, communicated to the Royal Society in July, 1927, in which the experimental results obtained in the Committee's tests serve as the foundation of a more complete theory. A brief account of the theory, thus developed, is included in the report, and the manner in which it has been applied to estimate the proper allowance for impact effect in bridges subjected to the action of locomotives of given characteristics is fully set forth. It may be said to have rationalised the complicated question of hammer-blow effects; it has demonstrated the meaning and consistency of results which, without it, would have been difficult to understand. It has also enabled an estimate to be made, with considerable confidence, of the greatest impact effects that are likely to be experienced on bridges of various types, under stated conditions of locomotive practice, thereby allowing numerical values to be tabulated for future guidance in design.

Tabulated Estimates of Load and Impact Effect.—Tabulated values are given in the report showing the estimated combined load due to weight and impact effects for a number of stated standards of loading with stated amounts of hammer-blow. The combinations selected for this tabulation cover, in the opinion of the Committee, such cases as are likely to present themselves in British railway practice. The assumptions underlying each group of tabulated values have been fully stated, so that engineers may be able to exercise their judgment as to how far the assumed data apply to any particular example that may have to be dealt with in design or in the use of an existing bridge.

The standards of loading selected for this purpose include such as seem sufficient to provide for any increase of loads that may be anticipated in British railway practice.

Effects of Resonance; Equivalent Uniformly Distributed Load.—In the estimation of impact effect the Committee has been primarily concerned with that part which is due to hammer-blow. The effect of hammer-blow, in all except the shortest bridges, is intensified by "resonance" arising from synchronism between the natural period or periods of the loaded bridge and the frequency of application of the blow. In most bridges this is the chief reason why an allowance for impact has to be made. But in all bridges there are, in addition, other causes of impact, such as rail joints and the lurching of locomotives. These are also discussed in the report, and numerical estimates are given of the allowances which, in the opinion of the Committee, should properly be made for them, in addition to the allowance proper for hammer-blow. For convenience in design, in relation to bending moment, the whole allowance for impact is most conveniently expressed in the form of an "equivalent uniformly distributed load," which is to be added to the estimated load arising from the weight to be carried.

Dynamic Magnifier.—In short bridges, where the natural frequency of the oscillation, even when the bridge is loaded, is markedly greater than the frequency of hammer-blow, effects of resonance do not occur, but the force of the hammer-blow itself is to be treated as an addition to the load the bridge carries. This also applies in general to cross girders. In longer spans there is magnification of the direct hammer-blow effect, in consequence of resonance. Continuity between the two cases is maintained by introducing a multiplying factor which the Committee calls the dynamic magnifier k. In a very short bridge k is unity; that is to say, the impact effect of the hammer-blow is simply equal to the amount of the hammer-blow itself; in spans beyond 30ft. or so k becomes somewhat greater than unity because effects of resonance begin to be felt; in longer spans, with much resonance, k may be many times unity. The report points out that the length of span is not the only determining factor; both the stiffness and the weight of the bridge have also to be considered.

Spring-borne and Non-spring-borne Loads.—When bridges that are long enough to give resonance are tested with the same locomotive running at various constant speeds, there is no very sharply defined maximum in the observed oscillation. This is largely because the natural period of the bridge varies during the transit of the load, as a result of variation in the amount of the oscillating mass. It is important to distinguish, in this connection, between the spring-borne and non-spring-borne part of the mass of a locomotive. If the springs remain locked—through friction—the whole mass of the locomotive shares the up and down motion of the bridge; if the springs are working freely, only a small part of the locomotive shares that motion. It was found, in the course of the experiments, that in certain cases both these conditions might occur. Locomotives differ much in the liveliness of their springs; and even with the same locomotive the springs may remain locked under moderate oscillation, but become operative under more violent oscillation. It is this consideration that gives rise to the two critical speeds referred to above. At the lower of the two speeds the springs are still locked; at the upper speed they are operative, and the system is then oscillating with a higher frequency in consequence of its lessened effective mass.

Damping.—When the locomotive springs are operative their friction dissipates much of the energy of oscillation, and consequently there is much more "damping" than is observed in the same bridge when the locomotive springs are locked. This has a most important result in limiting the magnitude which oscillation may attain under conditions otherwise favourable for resonance; it has a powerful influence in securing the safety of railway bridges. The damping effect of locomotive springs removes what might otherwise be dangerously sharp maxima in the resonance of a bridge under a suitably timed series of severe hammer-blows. In calculating tabulated values for inclusion in the report care has been taken not to make unduly favourable assumptions as to spring friction.

Double-heading.—The conditions of double-heading have been fully considered. The tabulated allowances for single-track bridges are based on the severe assumption that two engines may combine to produce the greatest possible effect by running at the critical speed or speeds, and in the same phase, so that they deliver their hammer-blows simultaneously. On a double-track bridge it is assumed that the load may be that which corresponds to four engines, two on each track, but in estimating hammer-blow effects only two out of the four are treated as running in phase at the critical speed.

Method of Calculation Used in Obtaining the Tabulated Impact Effects Due to Hammer-blow.—The method of calculating stress due to oscillation, under given conditions as to the characteristics of the bridge and of the locomotives used on it, is described by Professor Inglis. This method forms the basis of the numerical estimates of impact effect given in the report, so far as these are due to hammer-blow.

The method set forth has been applied to calculate, not only the impact allowances to be made for bending moment, but also those to be made for shear in designing the web members of the bridge. In addition to a table in which the total loads causing bending moment are stated in the form of equivalent uniformly distributed loads, other tables give the total shearing forces at three points of the span, namely, the centre, the three-quarter point, and the end. A third set of tables gives the total concentrated load on cross girders. In all cases impact is taken into account in the calculation of the tables.

Reduction of Hammer-blow.—The whole investigation emphasises the great importance of designing engines in such a manner as to reduce the hammer-blow. During the inquiry the Committee had the advantage, through the co-operation of Sir Henry Fowler, of being in touch with the locomotive engineers of the chief railways, who have shown themselves fully alive to the bearing of these results on the design of locomotives. The importance of reducing the hammer-blow is now widely recognised. It is gratifying to know that some of the work has already borne fruit in the disuse or alteration of certain classes, and in voluntary resolutions to impose certain limits on the hammer-blow in future locomotive designs. The report emphasises the advantage, from this point of view, of using three or four

cylinders rather than two, in the construction of heavy locomotives.

Particulars have been obtained as to the hammer-blows found in British locomotives generally, and these are set forth in the report.

Impact Allowance Under Restricted Conditions of Speed.—The proper allowance for impact depends essentially on the limit of locomotive speed. In tabulating impact allowances for general use in the design of railway bridges it has been assumed, as an upper limit, that hammer-blows may occur with a frequency of 6 per second, a condition which is approached in express running. In some railways, however, conditions are present which reduce the greatest speed of running to a figure which corresponds to a much lower frequency. On a railway where such conditions are permanently operative it would clearly be improper to determine the design of bridges by reference to a speed which cannot occur. There are lines where a suitable upper limit of frequency may be as low as 4½, or even 3. Accordingly, the figures which are stated in the report give the allowances for impact appropriate to these two limits, for use in cases where the speed is so definitely restricted as to make them applicable. The method of treatment which has been adopted has the advantage of enabling the engineer to discriminate on a rational basis between the requirements of railways where there are no special restrictions of speed and those where there are restrictions.

Relief of Stress and Distribution of Load.—The last section of the report deals briefly with such information as the experiments have incidentally furnished regarding the extent to which members of a bridge may be relieved of stress in consequence of the assistance afforded by adjoining members, and regarding the distribution of load over cross girders and floor members. In the conventional calculation of stresses borne by the members of a frame it is usual to ignore the support which members receive through stiffness at the joints. Stresses estimated on this basis are consequently, in general, somewhat higher, and may occasionally be a good deal higher than those actually observed under the same loads. Further differences of the same kind occur in bridges where the floor system is rigidly attached to the bottom members of the girder frames and so takes part in bearing the tensile stress due to a load. The report gives comparative figures for a number of cases which have come under the Committee's notice in the course of its tests. The most noticeable differences are found in bottom members or tension flanges to which the floor system is attached, and in trough girders. From records obtained in crawl tests some results are deduced as to the distribution of axle loads between closely spaced cross girders and also as to the influence of concrete bedding.

Tendencies in Steam Turbine Development.*

By H. L. GUY.

(*Concluded from page* 138)

WE have begun to conceive engineering materials at high temperatures as behaving in some measure as very viscous fluids. They are found to extend continuously, or "creep" under comparatively low stresses, at a rate which ultimately becomes approximately constant and which depends upon the magnitude of the stress and the temperature. It has been thought that if at any temperature the stress was sufficiently reduced this continuous extension would be arrested and this stress was named "The limiting creep stress." This "limiting creep stress" was usually deduced from tests in which measurements of creep rates were not carried below rates of strain of 10^{-5} per hour (*i.e.*, $^1/_{1000}$ in. in 100 hours per inch length).

Consider the significance of a creep rate of 10^{-6} per hour, which at 900 deg. Fah. might be expected in a mild 0·2 carbon steel if loaded to a stress of 6000 lb. per square inch. With such a creep rate a tube—such as a steam chest, steam pipe or turbine cylinder—18in. diameter if subjected to a simple tensile stress of 6000 lb. per square inch at a temperature of 900 deg. Fah. would increase in diameter at the rate of $^5/_{32}$ in. per annum. Or again, conceive a bolt and nut, when tightened up, as a spring holding two flanges together with an extension of 0·20/1000 per 1in. length. This extension corresponds to a load of 6000 lb. per square inch of bolt area. Then, if the stress on the bolt was maintained at 6000 lb. per square inch while the temperature was 900 deg. Fah. so that the creep rate was 10^{-6} per hour, the free length of the bolt would extend sufficiently in less than nine days to remove completely the spring force holding the flanges together.

On the assumption that a new phenomenon has been discovered concerning the action of stressed materials at elevated temperatures, it might be natural to suppose that advance into—what is at present a relatively unexplored territory—would be beset by all kinds of insoluble difficulties. Fortunately, such an assumption would almost certainly be wrong. A critical examination of published data, more refined experiment and the hypothesis of Mr. R. W. Bailey, suggest that creep probably takes place at all temperatures, but that the velocity of strain is very rapidly reduced as temperatures are decreased. If this be true, then in pursuing higher temperatures, we are not embracing the unknown, but can interpret the new conditions in terms of our present and past experience, providing certain essential data are available. For instance, test results on particular materials give some guidance to the engineer in determining the stress conditions which can be endured at 900 deg. Fah. and yet retain precisely the same physical conditions in his structure as he is already familiar with at 700 deg. Fah. Table III. gives the probable stresses and their ratios, deduced from the work of various experimenters.

Now, in the case of all those stationary structures of boiler and turbine plant which are subject to the full initial steam temperatures, the stress in them is practically proportional to the initial pressure. In particular this is true of steam piping, flanges and bolting, the high-pressure turbine cylinder, valves and details. It follows that by making use of such ratios as those in the two last columns of Table III., we can arrive at steam pressures on a particular element of a plant of definite material and dimension, which will result in the same creep conditions at both temperatures. Making use of such stress ratios we obtain the corresponding temperature-pressure conditions given in Table IV.

The difference in thermal efficiency obtainable with each pair of conditions is given in the last two columns. For example, suppose a given material has a certain creep rate at a definite stress when subjected to a temperature of 700 deg. Fah. and gives the same creep rate at 900 deg. Fah., but with the stress reduced to 40 per cent. Then if design is determined by this condition, a pressure of 400 lb. per square inch can be contained by an article of this material at a temperature of 900 deg. Fah. with the same safety as 1000 lb. per square inch with a temperature of 700 deg.

Compared thermally, the 400 lb. per square inch plant will be 3·9 per cent. more efficient than the 1000 lb. per square inch plant without feed heating and 1·1 per cent. more efficient if four-stage feed heating is taken to the optimum temperature.

At present our understanding of the phenomena involved, our knowledge of creep data, and the way in which such data should be interpreted, is very limited, even in the case of the more common materials of construction. Still the data used in the foregoing discussion is probably sufficiently accurate to justify the conclusion that with equal factors of safety on creep conditions for different combinations of temperature and pressure at least up to a temperature of 900 deg. Fah., the higher temperature condition will probably give the higher thermal efficiency.

The preceding discussion on the effect of elevated temperatures on the physical properties of materials, arose out of the conclusions that the most direct way of simplifying reheater systems is to eliminate their necessity by raising the initial steam temperature. Let us now consider what thermal advantages would result from the use of higher temperatures.

We have already seen that the direct use of high temperature steam on a simple condensing turbine plant is slightly more efficient than if the steam temperature is lowered by passing through a steam resuperheater before reaching the turbine stop valve. The thermal gains on the steam turbine itself per 100 deg. Fah. increase in total temperature between 700 and 900 deg. Fah. are plotted in Curve A—Fig. 6

If one stage feed heating is added and the effect of condenser and boiler-house auxiliaries is taken into account the relation of temperature increase to thermal gain is given by Curve B.

Curve C gives the gains per 100 deg. Fah. for a turbine fitted with four-stage feed heating, but without auxiliaries, while Curve D includes the effect of the auxiliaries.

The relatively small difference between this group of curves—about 10 per cent. between extremes—enables Fig. 6 to be used with accuracy for other combinations of feed heaters and auxiliaries.

In the case for the system employing four-feed heaters and including auxiliaries, it should be noted that within the range of pressures from 200 lb. to 1000 lb. per square inch g., the thermal efficiency of a complete plant is increased at the approximate rate of 4 per cent. per 100 deg. Fah. increase in total temperature. Within the pressure range 1000 lb. to 1500 lb. per square inch g. the thermal gain is approximately 4·5 per cent. per 100 deg. Fah.

The temperature increases which give definite increases in thermal efficiency in 3 per cent. steps are tabulated in Table V.

As the series of initial pressures and the steps in thermal gain are the same as in Table I., it is of interest to compare the changes in either pressure or temperature which give the same increase in thermal efficiency. Thus, for example, with an initial pressure of 350 lb. per square inch an in-

TABLE III.—*Ratio of Permissible Stress to Preserve the Same Rates of Creep at* 900 *Deg. Fah. as at* 700 *Deg. Fah. for Steel.*

Authority.	Reference.	Carbon per cent.	Limiting creep stress ratio 900 deg. F. / 700 deg. F.	Stress ratio for 900 deg. F. / 700 deg. F. Strain 10^{-5} per hour.
National Physical Laboratory ..	Report No. 2	0·51	0·36	—
National Physical Laboratory ..	Report No. 1	0·24	0·37	—
National Physical Laboratory ..	Report No. 1	0·17	0·37	—
R. G. C. Batson	Inst. C.E. Eng. Conference, 1928, Note No. 18	0·23	0·356	—
H. J. French and W. A. Tucker ..	Bureau of Standards, Tech. Paper No. 296 ..	0·24	0·327	0·408
J. J. Kanter and L. W. Spring ..	"Proc.," A.S.T.M., June, 1928..	0·33	(Cast steel)	0·397*
A. Pomp and A. Dahmen	Mitteilungen aus dem Kaiser Wilhelm Inst. für Eisenforschung, Vol. IX. (1927), p. 34 ..	0·40 0·23 0·046	— — —	0·46 0·39 0·53

* Deduced.

TABLE IV.—*Combinations of Pressure and Temperature which Give the Same Factor of Safety on Creep.*

Ratio Stress at 900 deg. F. / Stress at 700 deg. F.	Corresponding pressures, lb. per sq. in. g.		Thermal gain (corr. for auxiliaries) with higher temperature conditions.	
	At 900 deg. Fah.	At 700 deg. F.	No feed heating.	4-stage F.H. to temp. for max. gain.
			Per cent.	Per cent.
0·50	400	800	4·5	2·3
0·45	400	889	4·2	1·6
0·40	400	1000	3·9	1·1
0·35	400	1142	3·6	0·4
0·50	300	600	3·8	1·5
0·45	300	667	3·3	0·8
0·40	300	750	2·9	0·1
0·35	300	857	2·5	—0·7

INCREASE IN THERMAL EFFICIENCY WITH STEAM TEMPERATURE.

BASED ON :—Comparison of 700 *deg. Fah. to* 29*in. vacuum and* 900 *deg. Fah. to* 29*in. vacuum with four-stage F.H. to point of maximum gain. Result expressed as percentage of thermal efficiency with* 700 *deg. Fah.*

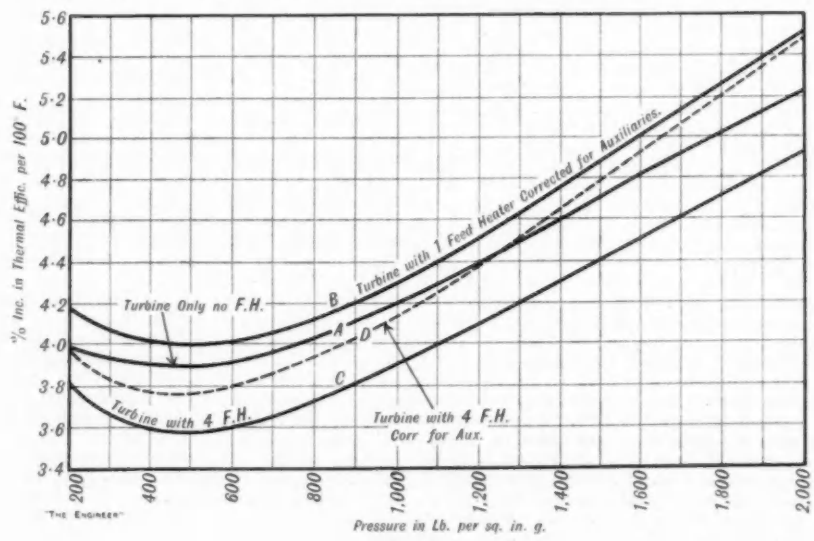


FIG. 6

* Inst. of Mech. Engineers. Read before the North-Western Branch in Manchester on January 31st, 1929.

crease of 408 lb. per square inch to a total pressure of 758 lb. per square inch gives the same thermal gain as would be obtained if the pressure was kept constant at

TABLE V.—*Increase in Total Temperature for 3 Per Cent. Steps in Thermal Efficiency.*

Basis.—700 deg. Fah. total temperature, 29in. vacuum, four-stage feed heating. Including boiler and condenser auxiliaries. Capacity not less than 4000 kW M.C.R. at 1500 r.p.m.; 2000 kW M.C.R. at 3000 r.p.m.; 1000 kW M.C.R. at 6000 r.p.m.

Increase in thermal efficiency ..	3%	6%	9%	12%
Initial pressure.	Increase in temperature, °F.			
200 lb. per square inch G. ..	77	151	227	302
250 lb. per square inch G. ..	77	155	232	309
350 lb. per square inch G. ..	79	158	237	
500 lb. per square inch G. ..	79	159		
750 lb. per square inch G. ..	77			
1400 lb. per square inch G. ..	65			
Reduction in coal consumption	2·92%	5·66%	8·26%	10·71%

350 lb. per square inch and the total temperature was raised by 158 deg. Fah.

Comparison of Tables I. and IV. also reveals the following interesting characteristics of pressure and temperature increases. If the total temperature is kept constant, the changes in pressure necessary to secure a given gain in efficiency increase very rapidly, both with the initial pressure and with the magnitude of the gain in efficiency considered. On the other hand, the increase in temperature necessary to secure a given gain in efficiency is sensibly constant at all initial steam pressures whether the step in efficiency be 3 per cent. or 12 per cent.

In contrast with increases in initial pressure, the thermal advantage of increased temperature does not sensibly depend upon the size of the prime mover. A further distinction arises from the fact that a much smaller proportion of the complete boiler and turbine plant is affected by raising the temperature than by raising the pressure.

Apart from the effect of increased steam temperature, on the physical characteristics of materials, the chemical action must be considered. In recent years, constructors have begun to think of the strength of materials in terms of temperature and time. A further consideration has now been introduced, necessitating the conception of strengths of materials in terms of temperature, time and the corrosive or other chemical action of the media, with which it is in contact. Thus, for instance, we know that the fatigue resistance of materials is very greatly reduced if they are subjected to corrosive conditions while being loaded. While a certain amount of research work in these matters has already been done and much more initiated, from its very nature it is costly in apparatus and even more so in time. The information already available is meagre and the phenomenon involved obscure. It is satisfactory to know that a comprehensive plan of research is under consideration, and that providing the necessary financial support is obtained from those most immediately concerned, a Government grant can be secured, and the work will be pursued energetically under conditions most likely to prove productive.

Increasing the initial temperature has one other important bearing on design. The coefficient of elasticity of steel at 900 deg. Fah. is only about 85 per cent. of its value at 60 deg. Fah. and 95 per cent. of its value at 700 deg. Fah. The deflection of any part of a steel structure is therefore 15 per cent. greater at 900 deg. Fah. than at 60 deg. Fah., and 5 per cent. greater than at 700 deg. Fah. For the same reason the critical speed of any steel part at 900 deg. Fah. is about 92 per cent. of its value at 60 deg. Fah., and 97 per cent. of its value at 700 deg. Fah. If, therefore, a shaft, for example, is to have its critical speed 25 per cent. above the running speed, and its mean temperature is 900 deg. Fah., then the critical speed at 60 deg. Fah. must be 36 per cent. above the running speed.

Regenerative feed heating—or bleeder heating—has become firmly established, the world generally having decided to follow the lead initiated in this country. Two tendencies are observable. In this country temperatures leaving the feed heaters are generally being raised, with the necessary result that the number of stages of feed heating is increasing. This is resulting in the addition of some air preheating coupled with retention of the economiser even if in an abbreviated form. In some other countries which adopted feed heating at a later date and practised elaborations never entertained here, the tendency is towards simplification. In such cases the number of feed heaters is tending to become fewer. Oil coolers and air coolers are being taken out of the feed heating circuit. Feed-heating temperatures, in general, tend to decrease slightly and economisers are showing signs of being reintroduced in conjunction with air preheaters where formerly the later device had developed to the entire exclusion of the former. Thus, from both extremes development is tending towards a moderately complicated system of multi-stage feed heating with both air preheaters and economisers.

The degree of complication in any respect desirable depends on the magnitude of the plant. For this reason, the number of feed heaters may be expected to vary with the capacity of the plant. Thus, for example, good practice might limit the number of feed heaters to one for sets up to 6000 kW, M.C.R. rating. For ratings up to 12,500 kW M.C.R. two feed heaters might be used; three or four stages may be desirable for 25,000 kW, while four or five stages may be proper to the largest plant. It is, however, assumed that the steam pressure will not be less than 300 lb. per square inch for the largest plant.

Air-ejector heaters are invariably placed in the feed heating circuit, but are additional to the provision just discussed.

The problem of the best disposal of feed-heater drains has not yet found a standard solution. Briefly there are three main types of treatment.

The Cascade System A, Fig. 7.—The drains may be led to the steam space of the next lower heater, the lowest being drained to the condenser. The hot drain water, on arrival at the lower temperature heater, is cooled by a certain proportion of steam flashing off, this steam making some contribution to the temperature rise in that feed heater.

The Separate Drain Pump System B, Fig. 7.—The drain from each feed heater may be taken to a separate pump and discharged into the main feed line at a point immediately after the heater. In order to visualise the duty of these drain pumps, consider the case of a four-stage feed-heater system, supplying a boiler operating at 375 lb. per square inch. The two final drain pumps must take about 5 per cent. of the total feed water in practically a boiling condition on the suction side and pump it against heads of about 950ft. and 1770ft. respectively. Such conditions are not conducive to high pump efficiency and such pumps are usually remarkable for low efficiency.

While the thermal efficiency of this system is approximately 0·9 per cent. higher than if drains are cascaded, it involves three serious objections:—

(1) A number of relatively small multi-stage pumps are added to the system, whose duty is difficult and imposes an inherently low efficiency of performance.

(2) The verification of guarantees based on this system becomes a difficult matter, as will be discussed later.

(3) The reliability of the plant as a whole depends on a number of relatively tiny pumps and their driving mechanism.

The Drain Cooler System C.—The sensible heat in the drain may be partially recovered by passing through tubular water coolers, through which the feed from the next lower heater is passed. Unfortunately, the transmission of heat from water to water through tube surface is relatively inefficient, because the necessary characteristics of the design involve a comparatively low water velocity on one side, with an extremely low one on the other. Further, the coolers are subjected to the same water pressures on the feed side and demand practically the same costly construction as the feed heaters they serve. Thus, if the rate of heat transmission is 100 B.Th.U. per square foot per 1 deg. Fah., and the final temperature difference of the incoming drain water and outgoing feed is to be 10 deg. Fah., the necessary surface and size of the cooler will be 1·38 times that of the feed heater it serves. Yet the heat transmitted in the drain coolers is only 17 per cent. of that of the feed heaters. If the rate of heat transmission can be raised as high as 200 B.Th.U. per square foot per 1 deg. Fah. per hour, the drain cooler will still require 69 per cent. of the feed heater surface.

By resorting to a less ambitious scheme of heat recovery in which the terminal temperature difference is increased from 10 deg. to 20 deg. Fah., the size of the drain cooler, with a heat transmission of 100, will still be 87 per cent. of that of the feed heater and 44 per cent. with 200 B.Th.U. per square foot per 1 deg. Fah. per hour. In this case the

FEED HEATER DRAIN ARRANGEMENTS.

Effect on Heat Consumption allowing for power to Feed Pump, Extraction Pump and Drain Pumps. Result is expressed as percentage decrease in Heat Consumption compared with Scheme A. Calculations are made for Four-stage Feed Heating to 350 deg. F., with 10 deg. F. difference in Feed Heaters between Feed Water outlet temperature and saturation temperature of tapped steam. Pumps assumed motor driven, with Feed Pump efficiency 70 per cent., Extraction Pump efficiency 40 per cent., Drain Pump efficiency 25 per cent., efficiency of each Motor 90 per cent.

Scheme.	Percentage decrease in heat consumption compared with Scheme A.				Remarks.
	600 lb. /sq. in. G., 700° F. to 29 in.vac.		350 lb. /sq. in. G., 700° F. to 29in. vac.		
	Excluding power to pumps.	Including power to pumps.	Excluding power to pumps.	Including power to pumps.	
A	0 (basis)	0 (basis)	0 (basis)	0 (basis)	
B	1·08	0·87	1·06	0·97	
C	0·87	0·88	0·89	0·89	10° F. min. temp. diff. in drain coolers
	0·69	0·70	0·72	0·72	20° F. min. temp. diff. in drain coolers
D	0·69	0·70	0·69	0·69	

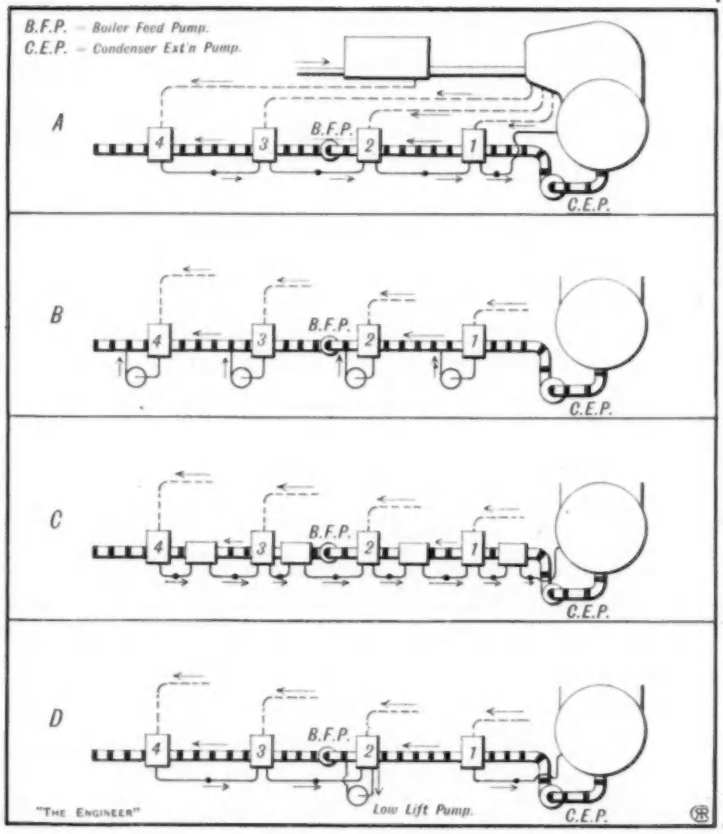


FIG. 7

heat transmitted in the drain coolers is only 13·6 per cent. of that in the feed heaters.

With drain coolers based on a 10 deg. Fah. terminal temperature difference the thermal advantage is 0·89 per cent. higher than the cascade system, the drain coolers becoming practically the same cost as the feed heaters themselves. With a 20 deg. Fah. terminal temperature difference the thermal advantage is reduced to 0·7 per cent.

The relative thermal advantages of these systems are illustrated in Fig. 7. Probably the most desirable treatment is the combination of the cascade and low-lift drain pump system illustrated in D, which combines most of the operating advantages of the cascade system and eliminates most of the difficulties of drain pumps in operation and testing, together with eliminating all the disadvantages of small multi-stage very high-lift extraction pumps. Further, the thermal advantage of this system is practically the same as the limit value for drain coolers and is only about 0·25 per cent. less than the ideal.

Whatever system of drain pumps is adopted, it is always desirable to have the necessary arrangements to enable the drains to be cascaded back to the condenser at will.

For some time past, chemical water treatment plant has tended to give way to evaporating plant. When first introduced, multi-effect evaporators, using boiler steam in the first stage, were commonly used. Nowadays, the tendency appears to be towards the use of a single-stage evaporator, the heating steam for which is taken from the turbine and the vapour from which is returned either to the condenser or back to the turbine to perform further work. In the general case, it is desirable either to insert a feed heater between the evaporator and turbine, or to exhaust the evaporator to the condenser, so as in the one case to reduce, or in the other eliminate, the risk of a priming evaporator discharging solid water into an operating turbine. In either case, the evaporators should be arranged to work with a small temperature difference across it, usually not exceeding 60 deg. Fah., so that the evaporator is coupled in parallel with a feed heater or replaces a feed heater tapping.

There is freedom of choice in the particular temperature step which is used in the total range from the stop valve temperature of, say, 700 deg. Fah., to the condenser temperature of perhaps 80 deg. Fah. The main considerations which should determine the selection of the temperature at which steam is taken are briefly as follows :—

(1) The character of the deposition of the scale forming matter *is*, with certain waters, affected by the temperature at which evaporation takes place. These may vary from one desirable form in which the deposit on the tubes is easily cracked off, to deposition in the form of sandy powdery deposits which precipitate to the bottom of the evaporator body. Examination of the water or previous experience may in such cases guide the selection of temperature.

(2) As the temperature is decreased, the volume of the steam increases and consequently the bulk and cost of the evaporator itself.

(3) Apart from considerations (1) and (2), placing the evaporator between the lowest feed heater tapping and the condenser has the advantage that the turbine is completely protected from any consequence of the evaporator priming badly. Further, the turbine exhaust is relieved of a certain amount of steam, with consequent improvement in its efficiency.

The addition of feed heaters, ejectors and evaporators to the turbine heat cycle, at first created some predicament in determining the conditions under which the performance of the turbine should be guaranteed and tested. In the author's opinion, giving due consideration to the exigency of station operation, even during contract tests, and to the dictates of internal turbine design, it is desirable for both the guarantees and tests to be limited to the conditions holding when the turbine feed heaters and ejectors are in operation. The evaporator should be shut down or by-passed for the period of the test. Testing under such conditions has, in fact, proved a much more simple matter than was formerly supposed possible. If the final feed temperature is below 195 deg. Fah. at sea level, the condensate can be satisfactorily weighed and measured in open tanks, after the last feed heater. The only precaution necessary is that the roof height, if any, above the tanks should be large. Loss due to evaporation in the tanks is a small fraction of a per cent., and can easily be measured within sufficiently close limits, by observing the loss of weight from the surface for the same time interval as one tank takes to fill during the test.

With feed temperatures above 200 deg. Fah., it has been commonly supposed that accurate tests cannot be carried out. This is not the case; at least three satisfactory methods, relying on direct measurement, are at our disposal. The method available depends to some extent on the way in which feed-heater drains are dealt with in the plant to be tested.

For such feed temperatures, the condensate is preferably weighed or measured at some intermediate point between the condenser and the outlet from the last feed heater. If a point at a desirable temperature is selected between consecutive feed heaters, the water must be returned to the feed-heater system after being measured. The disadvantage of this system lies in the fact that any leakage in the feed heaters above the point of measurement returns to the condenser and is erroneously measured as increased steam consumption. Where it is certain that the feed heaters are not leaking, it is probably desirable to measure the condensate before entering any of the feed heaters. The prevailing tendency to adopt duplicate extraction pumps facilitates these test arrangements.

In the first method, illustrated in Fig. 8, the feed leaving the last heater passes through a cooler, where its temperature is reduced below 195 deg. Fah. before passing to the measuring tanks. The outstanding advantage of this system is that any internal leakage from the water to the steam side of the feed heater is in a closed circuit, and does not introduce any error into the measurements.

The disadvantages are :—

(*a*) A second boiler feed pump is required to return the water to the boilers.

(*b*) The temporary water cooler is of considerable size and must be supplied with considerable quantities of cooling water. The cost and inconvenience of installing such temporary cooler and piping might represent a considerable charge.

(*c*) During the test the deed will be supplied to the boilers at a temperature much below the normal. This disadvantage can be discounted by using the water cooler as a feed heater on the counter-current principle, but such a course greatly aggravates disadvantage (*b*).

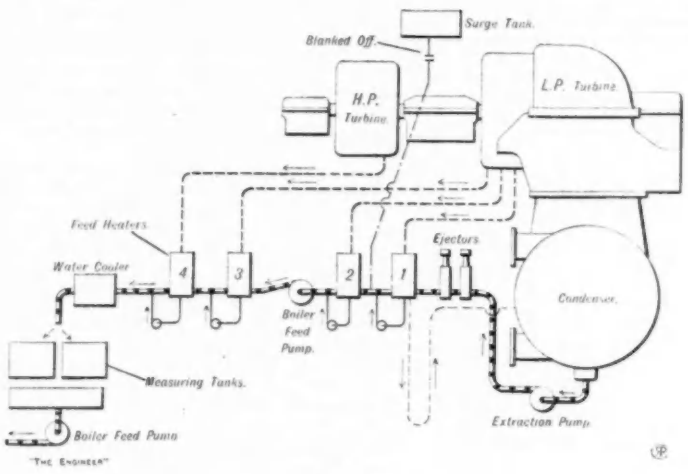


FIG. 8

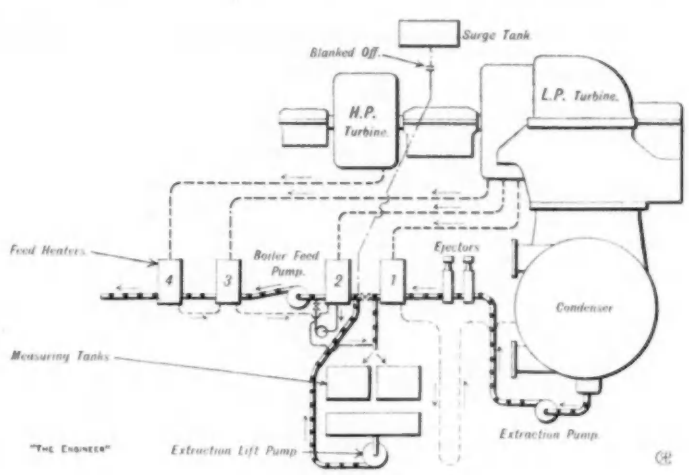


FIG. 9

The second method, illustrated in Fig. 9, is applicable to the case where there are no drain pumps on the high-pressure heaters. The feed can be intercepted between the low-pressure heaters where its temperature is manageable or even before the first heater.

The water from the low-pressure drain pump can be cooled by mixing with the main feed before discharge to the measuring tanks. A minimum of temporary gear is required with this method, and a convenient temperature can always be chosen. The disadvantage is, that any leakage in the feed heaters beyond the point of water measurement is returned to the measuring tanks *viâ* the heater drain. A source of error in test may be introduced thereby, since this leakage will be erroneously measured as adding to the steam consumption.

Separate static pressure test in the feed heaters will not necessarily reveal such leakage, because water leaks may be opened up by the deflections resulting in normal operation from temperature differences, which may be closed when the heater is at sensibly one temperature. The position is therefore precisely analogous to that arising from the possibility of condenser leakage when the circulating water is free from easily detected salts.

A simple expedient eliminates this difficulty. Chemical matter can be added to the water in the measuring tanks detectable at extreme dilution, and which is innocuous to the materials of the plant itself. The drain from each heater is separately sampled and tested. It is usually sufficient to detect the presence of leakage qualitatively, thus immediately demonstrating the presence of an error in the test and its source. The same method provides the means of quantitative assessment if desired, either by electric conductivity measurements or by chemical analysis.

The third method consists in cascading all drains straight back to the condenser, the condensate being measured in tanks placed immediately after the extraction pump in the way customary for plants without feed heaters. The feed from the test tank after measurement must be fed back to the system. Feed heater leakage can be detected as in the second method of testing. This last method is equally applicable to systems where normally drain pumps are operated. The necessary adjustment, if guarantees have been based on the operation of drain pump, is a simple matter of calculation. As its importance in heat consumption is of the order of 0·75 per cent., extreme refinement in estimates is quite unnecessary. Owing to the simplicity in testing which results, a great deal can be advanced for the adoption of cascading drains as a basis of all guarantees, even where drain pumps are employed in normal operation.

In tests of the kind outlined in this section, small correctives are necessary to the turbine performance for the following variations in feed temperatures from the contract conditions :—

(*a*) If the condensate supplied to the first heater is at a lower temperature than that on which guarantees are based. This may arise from variation in vacuum or from the fact that at a given vacuum the condensate is cooler or hotter than was expected.

(*b*) The feed may be cooled in passing to, from and and through the measuring tanks.

(*c*) The final feed temperature may be different from the guaranteed.

The limits of temperature variation which may arise in this way should be small and corrections can be arrived at with sufficient accuracy by making use of the relations given in Table VI. The last column has been added to indicate the very simple rule which assists in memorising this series of corrections.

TABLE VI.—*Correction for Variation in Feed Heating Temperature.*

Temperature rise in feed heaters.	Degrees temperature rise per 1% increase in steam consumption.	Difference.
0° to 50° F.	50° F.	
50° to 100° F.	30° F.	− 20
100° to 150° F.	20° F.	− 10 — 20 ÷ 2
150° to 200° F.	15° F.	− 5 — 10 ÷ 2
200° to 250° F.	12·5° F.	− 2·5 — 5 ÷ 2

If the temperature of the condensate leaving the condenser is depressed, the first feed heater is called upon to supply additional heat at a cost in steam consumption of 1 per cent. per 50 deg. Fah. defect in initial temperature.

While the corrections given in Table VI. can be used with confidence for the relatively small variations in feed temperatures likely to occur in tests, they are derived from the assumption that the feed heating system is provided with a separate feed heater for each 50 deg. Fah. step in temperature rise. If the feed heater steps are 100 deg. Fah., the appropriate correction will be that in the table which corrresponds to final temperatures of 100 deg. Fah. and 200 deg. Fah., and so on. Thus the first 100 deg. Fah. will be obtained with a steam consumption increased at the rate of 1 per cent. per 30 deg. Fah. or a total of 3·33 per cent.

Suppose the feed water is taken to the measuring tanks after its temperature has been raised in preceding feed heaters by 100 deg. Fah. Then the effect of any temperature drop in returning the water to the feed system calling for additional heating in the next heater is assessed at 1 per cent. in steam consumption per 20 deg. Fah. drop in temperature. The correction for any defect in temperature from the last feed heater will be obvious.

With feed-heating systems the performance of the turbine may be uniquely defined either by :—(*a*) A steam consumption ; (*b*) a heat consumption ; or (*c*) a thermal efficiency, providing the initial pressure and temperature of the steam, the vacuum at the turbine exhaust flange, the condensate and the final feed water temperature are stated. Of the three possible systems perhaps (*a*), the steam consumption, is the simplest, since it is concerned with the first quantity arrived at in the test itself and has long usage to commend it. It is, of course, just as "scientific" as either of the other alternatives.

The "heat consumption" (*b*) and the "thermal efficiency" necessitate contractural reference to the steam tables, which shall be used in calculating them from the steam consumption measured during the test, because for the same actual turbine performance the figure of merit deduced for (*b*) or (*c*) will vary with the steam tables chosen. On the other hand, the heat consumption has a special significance because of the ease with which it can be converted into coal consumption and station performance. This system is coming into increasing use.

A thermal efficiency basis for guarantees has neither of the advantages which can be advanced for the two former methods. In addition to requiring contractural reference to the steam tables on which it is to be based, its use requires also that the value of Joules equivalent to be adopted shall also be stated. This becomes necessary because it is the variable quantity which may give differences in the heat value of the kilowatt-hour. Very variable figures are current for this value. Table VII., based on Kaye and Laby, gives the value of this quantity in the last column which corresponds to the more important determinations of Joule's equivalent. Calculations of this kind would be facilitated if common agreement could be arrived at to adopt a value of 3412 as the British thermal units corresponding to 1 kilowatt-hour.

In order to illustrate the effect these systems of stating

performance have on the variation in turbine performance with steam conditions, test corrections have been plotted in Fig. 10 for a representative case.

The following points should be noticed :—

(*a*) The correction for initial steam temperature, vacuum and final feed temperature is much smaller if performance is expressed as heat consumption than as steam consumption, an advantage in favour of the former system.

(*b*) The correction for initial pressure and temperature with the feed heaters working is sensibly the same as with the feed heaters cut out.

The convenience of all concerned in handling steam plant would be served, and a great deal of unnecessary confusion avoided, if agreement could be reached on the exclusive use of one of the two former systems of stating guarantees and plant performances.

TABLE VII.—*Joule's Equivalent and Mean Heat Value of a Kilowatt-hour.*

$$\text{Thermal efficiency} = \frac{\text{(Heat value of a kilowatt-hour)}}{\text{(Heat supplied per kilowatt-hour)}}$$

Experimenter.	Date.	Ergs per mean calorie from 0° C. to 100° C.	Mean B.Th.U. per kWh.
Joule	1843	$4{\cdot}173\times10^7$	3423·3
Rowland	1880	$4{\cdot}186\times10^7$	3412·7
Reynolds and Morby	1897	$4{\cdot}180\times10^7$	3417·6
Griffiths	1894	$4{\cdot}194\times10^7$	3406·2
Schuster and Gannon	1896	$4{\cdot}194\times10^7$	3406·2
Callendar and Barnes	1909	$4{\cdot}184\times10^7$	3414·4
Bousfields	1911	$4{\cdot}181\times10^7$	3416·8
Jaeger and Steinwehr	1921	$4{\cdot}186\times10^7$	3412·7
Laby's weighted mean	—	$4{\cdot}186\times10^7$	3412·7

TEST CORRECTIONS.

STEAM CONDITIONS.—350 lb. per square inch G., 750 deg. Fah., 29in. vacuum, four-stage feed heating to 300 deg. Fah.

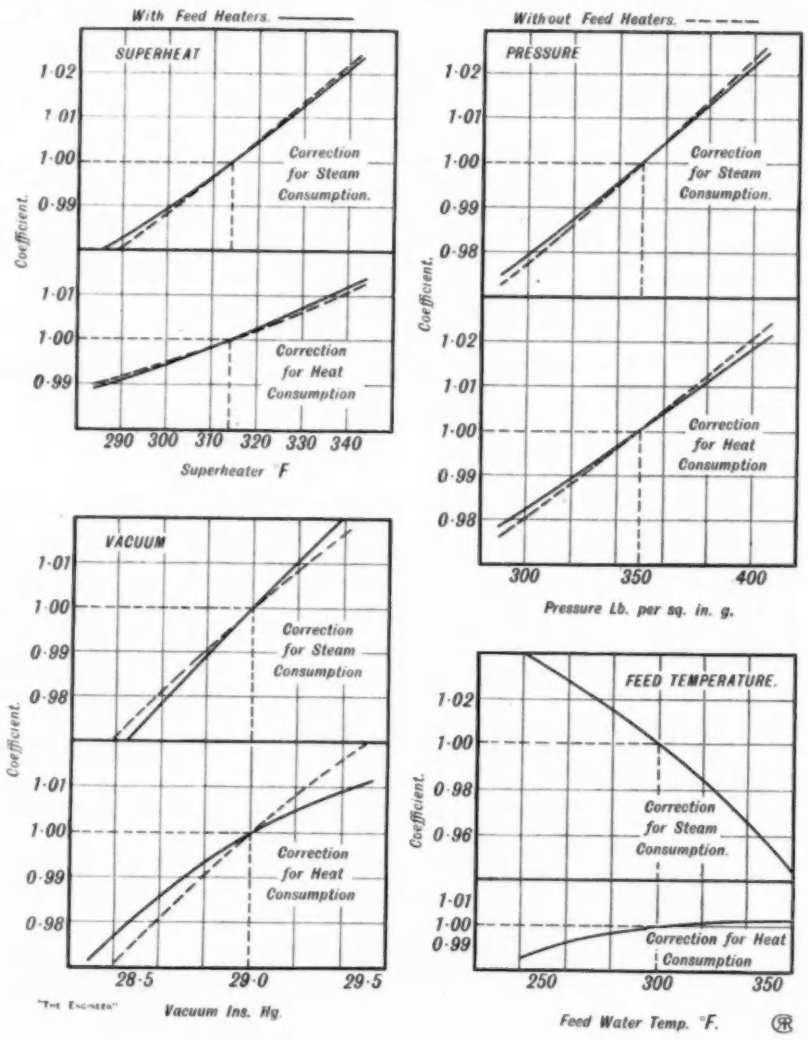


FIG. 10

The balance of advantage appears to lie in selecting the second method of stating performance in terms of "heat consumption" per kilowatt-hour. Further, in feed-heating installations, performances should be required only with the feed heaters in operation, and preferably with the drains cascaded to the condenser. The steam for air extraction, if any, should be included in the guarantee but evaporator steam should be excluded. Contractural reference to performance with the feed heaters by-passed should, in the best interest of the purchasers, never be required or stated.

Calculations have been based on "The Enlarged Callendar Steam Tables." Occasionally, to avoid unnecessary repetition, basic assumptions have been omitted. In such cases the assumptions are the same as were adopted in the author's earlier paper, "The Economic Value of Increased Steam Pressure."

In conclusion, the author desires to thank Messrs. Metropolitan-Vickers for permission to utilise investigations which, for the most part, arose in normal work of the mechanical engineering department ; Mr. K. Baumann and Mr. R. W. Bailey, M.Sc., for suggestions and advice ; and Mr. D. M. Smith, B.Sc., for patient work in the preparation of the diagrams.

THE IRON AND STEEL INSTITUTE.

THE annual meeting of the Iron and Steel Institute will be held on Thursday and Friday, May 2nd and 3rd, 1929, at the House of the Institution of Civil Engineers, Great George-street, London. At this meeting Professor Henry Louis will assume office as the President, and the meeting will take place under his presidency.

The annual dinner will be held on the evening of Thursday, May 2nd, at the Connaught Rooms, Great Queen-street, London, W.C. 2.

At the invitation of the Lord Mayor and Corporation of the city of Newcastle-upon-Tyne, the autumn meeting will be held at Newcastle, having been fixed to take place there in the week commencing Monday, September 9th. Further particulars concerning the arrangements for the meeting and visits to works will be circulated later.

Autumn Meeting in the United States in 1932.—At the annual general meeting in May, 1928, Mr. Charles M. Schwab, President of the American Iron and Steel Institute, presented, on behalf of the American Institute of Mining and Metallurgical Engineers and the American Iron and Steel Institute, a very cordial invitation to the Iron and Steel Institute to meet in the United States in 1932. The President, Council and members expressed their grateful acknowledgments and accepted the invitation with great pleasure.

Carnegie Research Fund.—In March of each year applications for grants from the Carnegie Fund are considered by the Council. A limited number of grants is awarded, irrespective of nationality or sex, in aid of research work on some subject of practical importance relating to the metallurgy of iron and steel or allied subjects, and applications must be made on special forms to be obtained from the Secretary of the Institute. Candidates, who must be under thirty-five years of age, must send in their applications before the last day of February. Recipients of grants are expected, on completion of their research work, to communicate the results to the Institute in the form of a report.

The Williams Prize.—The "Williams Prize," founded in 1926 by Mr. Illtyd Williams, is offered for award by the Council to the author or authors, of British nationality, of the paper which is adjudged to be the best paper of a practical character presented to the Institute and accepted for publication at any general meeting during the year. The prize is approximately of the value of £100, and to be eligible for the award authors of papers coming within the scope of the scheme must be in regular employment in an iron and/or steel works in the United Kingdom or in a British Dominion, in a position not superior to that of manager of any one technical department.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

FACTORY INSPECTORS.

SIR,—In that interesting feature of your journal which you entitle "Sixty Years Ago" you have just resuscitated the idea of the factory inspector, and have thereby suggested that such inspectors are of a service to industry ; but it is difficult to associate such an idea with your previously stated policy of retrenchment which was then prevalent, and was succeeded by a wave of prosperity in this country, which, it may be justly presumed, was the outcome of our industries being allowed to "fight their own battles."

Now the point which I want to emphasis is this. Despite factory inspectors and the Home Office rules under which they have worked for, as you suggest, at least sixty years, the artisan himself cares so little for these ostensible safeguards over his health that he will neglect them on the first opportunity. One only has to go into a grinding or buffing shop to substantiate this statement.

And so it arrives in either one of two ways. Either that the people who are so careless of the safeguards which our legislators have provided for them are not worthy of the expense thus entailed, or that that expense might be more profitably expended on educational affairs long before the worker ever arrived in the factory.

Do you, Sir, and your readers, not feel that the time has re-arrived when a personal interest should be devoted to our workers, starting from their early days, rather than that they should be taken, almost indiscriminately, from a general supply ?

It would, of course, entail considerably more care on the part of those whose business it is to "sign on" new labour, to choose only those who were competent for the job in view. On the other hand would it not really be worth while in the end ? An assurance that *those* men were capable of taking care of themselves would eliminate all the need for the costly business of factory inspection.

February 4th. D. G.

L.M.S. HIGH-PRESSURE LOCOMOTIVE.

SIR,—Your correspondent Mr. W. B. Thompson, in last week's issue of THE ENGINEER, seems to think it curious that the London, Midland and Scottish Railway should have decided to try out the Schmidt-Henschel high-pressure type of locomotive. If Mr. Thompson will refer to my letter in THE ENGINEER of June 22nd last year, he will there see one very sound reason, the high-pressure design showing a coal consumption of 2·32 lb. per D.B.H.P. hour, against a round 3 lb. for three British modern designs, and one of the best French compound designs. These latter on the basis of draw bar horse-power do not seem to show any economy over the best British non-compound types.

Mr. Thompson cites the brilliant work of the compounds of the Nord Railway, but it does not follow that it is lack of engine power that causes un-brilliant work on the Southern Railway, and also it is probable that the Nord would get brilliant work out of any decent type of locomotive on the Calais–Paris journey. Anyway, Germany, Austria, and Italy have experimented very largely with all sorts of compounds, and all three of them seem to be going back to simples. I think it is very gratifying that both the L.M.S. and the L.N.E.R. are enterprising enough to experiment with a type of locomotive that offers such a big improvement, although it is very complicated.

C. M. KEILLER.

Cookham Dean, Berks., February 4th.

RAILWAYS' CROSSINGS ON THE LEVEL.

SIR,—In the current issue of THE ENGINEER the interesting note on the Ashchurch accident—page 131, col. 1—mentions several examples of railways crossing on the level, but omits two important instances on a main trunk line from London. The crossings in question are situated on the L.N.E. (old G.N.) main line within 18 miles of each other. One is the intersection with the L.M.S. (old Midland) line from Nottingham to Lincoln, and is about ¾ mile north of Newark Station. The other is at the south end of Retford Station, at which point the G.N. is crossed by the main east to west line of the former, Manchester, Sheffield and Lincolnshire Railway from Manchester to Grimsby. I should be interested to know when these were respectively constructed. The Retford example is, so far as I can trace, the sole instance in this country of a flat crossing between two genuine main routes.

HORACE MYERS, Major.

London, N.W. 3, February 4th.

ABOUT Christmastime as much as 2½in. of rain fell at Shabani, Rhodesia, in 35 minutes. The water found its way into the asbestos mine there, and several natives were drowned.

Two New Rail Cars for Overseas.

IN the issue of THE ENGINEER for May 18th, 1928, we described and illustrated a new type of geared steam rail car, which was built at the Nottingham carriage and wagon works of Cammell Laird and Co., Ltd., and was engined by the Sentinel Waggon Works, Ltd., of Shrewsbury, for service on the London and North-Eastern Railway Company's system. Among the outstanding features of this new series of cars were the special 300 lb. pressure "Sentinel" boiler and the 130 B.H.P. six-cylinder single-acting horizontal engine. The engine, it will be recalled, is placed transversely beneath the car, and is coupled by a cardan shaft to a spur and bevel gear drive on the front bogie.

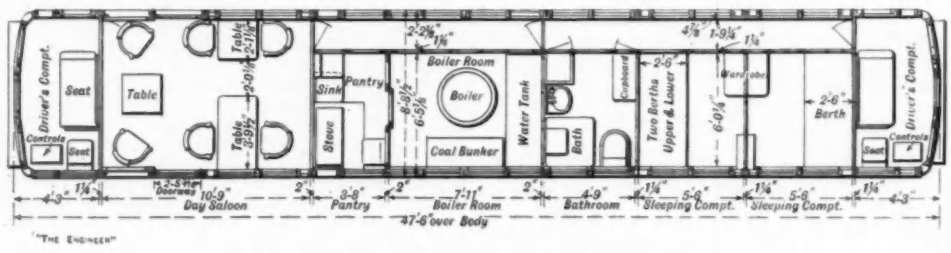
A few days ago we accepted the invitation of the same two builders to inspect under steam at Nottingham two new rail cars, which, while being fitted with the same type of power unit, both possess novel features in design. The two cars are illustrated on page 158. The first is one of four double articulated steam rail cars which have been built for the Palestine Railways and the Hedjaz Railway, and the second is a steam rail inspection car which has been specially designed for the use of the general manager of the Leopoldina Railway in Brazil.

The Double Articulated Rail Cars.—One of the special features of these four vehicles is that two of them are built for the 4ft. 8½in. gauge of the Palestine Railways and two for the 105 cm., or 3ft. 5⅜in. gauge of the Hedjaz Railway. The bodies and underframes have been so designed, however, that by changing the bogies any of the four cars can be made to suit the other gauge. Provision is made on the headstocks to take either the normal type of side buffers or the special centre buffer and drawgear of the Palestine narrow-gauge lines.

We show in Fig. 1, page 158, a side view of a car in the rear driving cab, and is complete with its own luggage compartment. The two third-class compartments, seating thirty-five and forty-two passengers respectively, are arranged at the articulated ends, and are also transversely seated. The backs of the seats which are of the lath and space type and are made in pitch pine, are reversible. The third-class luggage compartment is forward, next to the driving cab. Lavatory accommodation is provided for both classes of passengers, native and European. There are hinged doors in all partitions, so that communication from one end of the car to the other is given. Ventilation has been carefully considered and particularly so in the boiler compartment, which, besides side and front windows, has a ventilating deck with louvres on the panels. We found this compartment quite cool. The outside of the cars we have described is finished in sprayed-on cellulose enamel, the normal gauge cars being chocolate colour and the narrow-gauge cars grey. The bodies are to be shipped as assembled, and the normal gauge cars will travel to Liverpool on their own bogies.

The Leopoldina Steam Rail Inspection Car.—This car we found to be of particular interest, on account of the problem in design which was presented, and which has been so successfully solved by the builders. In a space of approximately 48ft. in length and 8ft. wide, the contractors have provided, besides living and inspection facilities, sleeping and dining accommodation for four people, together with a bathroom and kitchen. There are six external doors to the car, and no less than nine internal doors.

As will be noted from the accompanying drawing the boiler compartment is arranged in the centre of the vehicle, which leaves either end available for the required observation compartments. The car is a little shorter than the standard "Sentinel-Cammell" vehicle, owing to the fact that it will have to be taken on occasion high up into the Sierras of Petropolis and Friburgo, on which lines there are curves with a radius of 35 m. The car is designed to negotiate curves of 60 m. radius under its own steam. In general, the design of the underframe and bogies follows standard practice, but the wheels are all 3ft. 1in. in diameter. Both vacuum and hand brakes and



PLAN OF LEOPOLDINA RAILWAY INSPECTION CAR

sidings of Cammell Laird and Co., Ltd., adjoining the L.M.S. main line at Nottingham. It will be seen that the complete vehicle comprises two separate bodies, which are mounted on three bogies, the two adjacent ends being articulated on the Gresley patented system.

In the following table some of the principal particulars and dimensions of the cars are given :—

Length over body ends	97ft. 8in.
Length over buffers	102ft.
Width of body	8ft. 6in.
Height to top of roof	11ft. 5in.
Wheel base of all bogies	6ft. 6in.
Wheel diameter	2ft. 6in.
Boiler pressure	300 lb. per sq. in.
Engine output at 500 r.p.m.	130 B.H.P.
Total running weight	43 tons
Total fully loaded weight	49 tons

The engine cab is placed at the front end of the leading bogie and this compartment has an overall outside length of 11ft. 4in., with a total overall width of 8ft. 6in. In the centre of the compartment forward there is the boiler, which is centrally fired from the top and is totally enclosed in planished steel lagging. A plain fire-grate is fitted. To the right of the boiler are the driving controls and to the left the hand brake and boiler safety valves. At the back of the cab is a totally enclosed coal bunker, which is filled from the top, alongside of which is arranged a Pyle National 1500-watt steam turbine-driven generator for the car headlights and lighting service. At the rear end of the car is a smaller driver's compartment, with similar engine and brake controls. The control rods run the entire length of the car and are connected together by a single universal joint, just above the centre bogie pin. The controls, we found, are very easy to manipulate, and the operating handles are removable, one set only being provided for the two driving ends. Following the builder's standard practice, the direct-acting type of vacuum brake is fitted to these cars, and sanding gear is arranged for the two outer bogies, which, as will be seen in Fig. 1, are fitted with standard steel cow-catchers.

Interest attaches to the means provided for inspecting the engine. The cylinder covers are accessible from the side of the car. They are on the offside of the car in Fig. 1, but can be seen in Fig. 4. As the engine is placed transversely below the floor of the luggage compartment, immediately behind the leading driving cab, good top access to it is given by means of removable panels in the slatted floor, and the design is such that there is no need for an inspection pit.

We were able to try the car for engine vibration, and it may be remarked that during the short runs we made it was very difficult to tell at any part of the car that the engine was running. As observed from the side of the track, the car was noticeably silent.

In Fig. 2 we show views of the first and third-class compartments. The first-class compartment is designed to seat twelve persons, and the transverse seating is finished in blue leather of the railway company's standard shade. A gyratory electric fan is provided in the roof of this compartment, which is immediately forward of the standard sanding gear are fitted; while the railway company's own central type buffers with safety chains and cow-catchers are provided.

The boiler and engine are generally similar to those on the Palestine and the L.N.E.R. cars, but rocking grates and a spark arrester are employed.

The following are some of the principal dimensions and particulars :—

Length over headstocks	48ft.
Width over car body	8ft. 8½in.
Height to top of roof	11ft. 6½in.
Centres of bogies	30ft. 6in.
Engine bogie wheel base	6ft.
Trailer bogie wheel base	6ft.
Diameter of wheels	3ft. 1in.

From a series of excellent interior views placed at our disposal we have chosen three for reproduction in Fig. 4 page 158. They show the 11ft. 9½in. wide corridor, which extends from the rear driver's compartment to the day saloon. The corridor has one intervening partition which is fitted with a swing door. One of the driving compartments is also shown in Fig. 4. There are in this compartment seats for four passengers, and a tip-up seat for the driver, with the usual engine and brake controls and instruments and a pedal operated bell signal. At night the seats may be so arranged that sleeping accommodation is provided for two attendants, one in each cab.

The two main sleeping compartments are immediately forward of the driving compartment at the engine end, and two 2ft. 6in. berths are provided in each compartment, with a sliding door between the compartments. Excellent bathroom and lavatory accommodation, access to which is obtained from the corridor, is provided. The boiler compartment is neatly arranged with its coal bunkers and feed tanks.

Between this compartment and the day saloon is a combined pantry and kitchen. The day and dining saloon shown in the centre of Fig. 4 has a length of about 11ft., with a width of nearly 8ft. It is panelled in oak and has two removable tables and one collapsible table. There are two sliding doors, one on either side, each giving a clear opening of 2ft. 5⅞in., while swing doors give access to the driving compartment and the corridor.

The car is lighted throughout on the "Stone" system, and a searchlight is fitted at each end. The general ventilation is by means of torpedo fittings, and special boiler compartment ventilation is obtained by the provision of a ventilation deck overhead, which is equipped with louvres. The car is well adapted for the work it will have to perform.

The total cost of running such a car as that described in the foregoing, including coal, oil, wages, depreciation and stores, does not, the builders state, exceed on an average 1s. per mile, and they suggest that similar cars, fitted entirely with sleeping berths, would fill a long-felt need in certain railways at home and abroad on which at present the number of passengers travelling does not warrant the use of ordinary sleeping cars.

South African Engineering Notes.

A Rock Drill Factory.

DURING the past three or four years the town of Port Elizabeth has made remarkable progress as an industrial centre. The establishment of factories of various kinds, notably the motor car assembly works of General Motors and of the Ford Motor Car Corporation, and of a number of large boot factories has made the town one of the most prosperous and progressive of the Union, while, as a port, it is also remarkably busy. Another most interesting development, and one of the very greatest importance to mining in South Africa and to industry generally, is the fact that a very influential overseas firm has for months been making investigations at Port Elizabeth with a view to the establishment of a rock drill factory there. It is now announced that a large area of ground has been secured at that town, and that a factory, to cost about £250,000, is to be erected thereon. Presumably the intention is to import the various parts of the machine drill, drifters and lighter stoping machines, &c., and to assemble them there. The market for rock drills, accessories and rock drill spares in the Union and adjacent territories is a very large one, and it is still continuing to expand.

Mining Equipment.

The various firms overseas which tender for the equipment of the mines in South Africa should be taking particular notice of the Far East Rand from which considerable business should be obtained during the year just begun. The steady development of the East Geould and Daggafontein Mines and the reopening of the Wetpoort Gold Areas and the enlarged Nigel, are bright features of the outlook. Since the Road Collieries and the old Nigel were closed down, mining machinery and plant has been materially improved, and in many directions entirely new equipment will have to be installed on these properties. It may be too early yet to discuss reduction plants for the East Geould, Daggafontein and Witpoort Areas, but it is known they will include several important innovations. It is also very possible that the Grootolei property of Lewis and Marks may during the coming year be restarted, the financial arrangements having already been provisionally completed. Also adjoining the Nigel is the big Government lease ground unsuccessfully offered for tender some time ago. It would not be surprising if something were done to work it in the new year. Altogether it would seem that if the native labour supply permits next year may be one of great activity on the Far East Rand. Fortunately the treaty recently arranged with Portugal, in regard to its Mozambique Colony, of which Laurenço Marques (Delagoa Bay) is the capital, will not be ratified by Parliament—if Parliament does ratify it—in time to affect the Rand Mines next year. Under the new treaty instead of the mines being allowed to have 115,000 Mozambique natives, the number is to be reduced, during the next five years after the treaty has been passed by Parliament, to 85,000 natives from the Portuguese territory. The loss of 30,000 natives will mean that 3000 Europeans less will be employed. It may also mean to several mines that a bare profit will be converted into a substantial loss followed by the closing down of those mines.

Railway Construction.

The mileage of the South African Railways open, as at November 10th, 1928, was 12,651. The latest additions to this total are the George–Knysna line of 42 miles, and the Louis Trichardt deviation of 7¼ miles. Although 469¼ miles of the 1925 programme have been completed and opened for traffic, there is still a big section of this programme under construction.

Tenders for Locomotives.

It was officially announced, in the middle of December, that the South African Railways Administration intended within the next few weeks to invite tenders for the supply of forty new railway locomotives at an estimated cost of £300,000. Additional rolling stock is also to be ordered, tenders having already been invited for 100 four-wheeled trucks, 50 bogie fruit trucks, and 30 second-class saloons. This is in addition to the rolling stock recently ordered, and to cost £500,000. The Administration is continuing its progressive policy of conducting experiments with various types of rolling stock, with a view to the satisfactory development of the railway system. The latest enterprise is a steam rail coach which can operate as a single unit. It is to be capable of accommodating sixty or seventy passengers, and to be provided with a luggage compartment. The car when operating as a single unit will be capable of a maximum speed of 45 miles an hour on the level.

The general manager of railways has just announced that the Administration has decided to order 1050 additional trucks, made up of 600 40-ton bogies, 150 bogie cattle trucks, 300 four-wheeled cattle trucks, at an estimated cost of over £500,000. This number, added to those under construction, ordered or authorised to be ordered, will enable over 1,000,000 more tons to be carried during the peak period of the year ending March 31st, 1930, than will be carried this year. Among other new material, &c., authorised to be ordered is much new machinery for Salt River Works, large quantities of 6in., 7in. and 8in. piping, the re-sleepering of about 300 miles of track, while about 200 miles of rails are to be replaced by heavier sections. In some parts 45 lb. rails are to be replaced by 60 lb. rails, in other parts new 60 lb. rails are to replace old, and the Sea Point Line, which has now been electrified and is about four miles in length, is to have its 60 lb. rails replaced by 80 lb. rails. For the road transport routes a large number of Thornycroft vehicles, forty in all, has been ordered. Some of these are long type XB, other EC., and some A4 type. Eleven of the Thornycrofts will have trailers. Only four motor vehicles have been ordered from elsewhere, and they are all "Whites."

Railway and Road Matters.

THE number of engines on the Great Western Railway which are equipped with automatic train control totals 250.

TWENTY miles of railway are to be reclaimed from the branch from Battersby Junction, on the Whitby–Middlesbrough line, and to Rosedale and its subsidiary branch from Blakey to East Rosedale. Both were built in the Cleveland boom; the former was opened on March 21st, 1860, and the latter on August 18th, 1865. They are characterised by very heavy gradients and the summit is 1400ft. above sea-level.

CONSEQUENT upon the promotion of Mr. Raymond Carpmael to the position of chief engineer, Great Western Railway, the following further changes are announced:—Mr. E. G. G. Matheson becomes assistant chief engineer—works and structures—Mr. A. S. Quartermaine is to be the assistant chief engineer—permanent way and docks. Mr. S. W. Moore succeeds Mr. Quartermaine as divisional engineer, Bristol, and Mr. J. E. S. Griffith goes to Neath to replace Mr. Moore.

WRITING in the *Locomotive Journal*, Mr. John Bromley, of the Associated Society of Locomotive Engineers and Firemen, says that his Executive has sought for a meeting with the railway general managers on the question of passing signals at "danger," especially with regard to signal failures, and that such a meeting would shortly take place. Meanwhile, he would strongly appeal to the members, both drivers and firemen, to be exceedingly careful, to take no risks which might involve them in danger of personal injury or death, or in punishment, and to study always Safety First.

THE inquiry by Lieut.-Colonel Mount into the Ashchurch collision of January 8th has been prolonged by charges of alleged failures of signals in that district during the last year or so. In giving evidence at the resumed inquiry on the 31st of January, Mr. Sayers, the L.M.S. Railway telegraphs superintendent, said that there were 16,124 electrical repeaters of signals on the system, and that during the last two years there had been twenty-two cases of failure on the "danger" side reported. That meant one failure on the "danger" side in about 10,000,000 operations. We would add that, presumably, these failures were of signals being "off" when the repeater indicates "on."

THE Canadian Pacific Railway has prepared an extensive programme for the construction of branch lines in the Canadian West, embracing a mileage of nearly 1200 and involving an expenditure of 50,000,000 dollars, for which sanction of Parliament will be asked. The company proposes to enter the mining region of northern Saskatchewan, serving a large area in that Province and in Northern Alberta, and providing a connection with the lines recently purchased from the Government of Alberta, and furnishing an entrance to the Peace River district. The programme also includes a line to Falconbridge township in the Sudbury district of Northern Ontario, which which has lately come into prominence as a mining area.

THE Ministry of Transport statistics for October last have recently been issued as a Stationery Office publication, price 3s. 6d. They show that, compared with the corresponding month of 1927, there was an increase of 0·8 per cent. in the number of passenger journeys. There was an increase of about 5 per cent. in the number carried at cheap fares and a fall of over 4 per cent. in those paying ordinary fares. As a result the receipts from passengers fell by 4·3 per cent., whilst the passenger train mileage was 5 per cent. higher. Freight traffic was less disappointing than in previous months, as the tonnage decreased by only 0·6 per cent. and the receipts by 1·7 per cent. There was, moreover, a better movement in the freight trains, as the net ton-miles per engine-hour rose from 423¼ to 439.

ACCORDING to the Board of Trade returns, the value of the railway material exported during the twelve months ended December 31st last was as follows; the corresponding figures for 1927 and 1926 are added in brackets:—Locomotives, £3,501,220 (£2,286,543, £3,043,131); rails, £3,437,000 (£3,587,623, £1,347,623); carriages, £2,475,176, (£3,113,502, £2,732,908); wagons, £3,088,735 (£3,172,437, £2,731,984); wheels and axles, £742,194 (£860,764, £422,765); tires and axles, £592,283 (£728,076, £289,041); chairs and metal sleepers, £864,778 (£1,392,860, £638,639); miscellaneous permanent way, £1,306,456 (£1,488,733, £1,096,364); total permanent way, £7,079,948 (£8,318,164, £3,696,136). The weight of the rails exported was 393,667 tons (429,391 tons, 164,317 tons), and of the chairs and metal sleepers 88,114 tons (140,453 tons, 65,618 tons). During the month of December alone locomotives to the value of £297,447 were shipped overseas, which included:—South Africa, £62,330; the Argentine, £42,060; India, £34,911; Spain, £19,552; and other countries than the Argentine in South America, £13,841. During the same month the rails shipped were of the value of £198,036, and included:—South Africa, £64,131; the Argentine, £55,422; India, £42,509; Straits Settlements, £4967; Australia, £3608; West Africa, £2551.

WHEN lifting a rail joint on an electrified section of the Southern Railway, one of the gang was using a beater to pack the timber. The space between the lower flange of the conductor rail and the running rail was 10¾in. The beater had two insulating joints, one on each side of the shaft socket, but there was an unprotected section of from 8in. to 10in. between the beater head and the first insulating joint. The beater was apparently deflected, and, coming in contact with the flange of the conductor rail and the head of a chair spike of the running rail, a short-circuit was established, and a severe flash, rising to a height of from 30ft. to 40ft., accompanied by smoke, took place. In their alarm the men stepped back, and two of them ran into the path of an oncoming train on an adjoining line and were killed. The men are provided with rubber mats for use in such work, and Mr. Main, of the Ministry of Transport, in reporting on the accident, recommends that their employment, when work of any kind has to be undertaken adjacent to the conductor rail, should be rigidly insisted upon, as complete insulation of tools employed generally in maintenance work is not seemingly practicable. The railway company, immediately after the inquiry, gave orders that in all circumstances the mats are to be employed in future.

Notes and Memoranda.

IT is claimed for the Vereeniging Steel Works, Transvaal, that they are unique in that it is frequently necessary to change the rolls as often as three times a day to meet the demands for various sections. The cogging mill there is now producing high-grade steel billets for tube-making at the rate of 500 tons a month.

THE results of the study made by the Bureau of Mines and the Natural Gas Association of America show conclusively that after the main joints of a gas transmission system are installed properly, the largest part of the leakage is from connections and fittings on the lines. A satisfactory method of testing pipe lines for leakage has been devised by the Bureau; the laws governing gas leakage have been determined; typical transmission lines have been surveyed; and possible improvements in the construction and operation of transmission lines have been outlined. The economic aspects of preventing leakage have been studied.

THE maximum output ever concentrated in one transformer unit is probably, according to American news, represented in the 83,333 kilovolt-ampère auto-transformer which has been built at the Pittsfield works of the General Electric Company of New York for use in the Charles R. Huntley Station of the Buffalo General Electric Company. The unit is of the three-phase, water-cooled type, and has an output, at 25 cycles, of 83,333 kilovolt-ampères, 24,500Y—12,000Y volts. Based on its equivalent transformer capacity of 49,200 kilovolt-ampères, it required parts that could be used in building a 60-cycle, two-winding transformer rated at about 100,000 kilovolt-ampères at the same voltage. The transformer occupies a floor space of 23ft. by 14ft., and stands 14ft. over the top of the cover. It weighs 115 tons, and when filled with the necessary 13,300 gallons of oil, weighs 165 tons. The core alone weighs 58 tons. The conservator tank, which holds more than 1000 gallons of oil, is 192in. long and 40in. in diameter.

AMERICAN aviators have recently been trying to find a means of determining the altitude of flying machines by photographic methods. For this purpose the Corps of Engineers at Wright Field sent a detachment to make six closed traverses aggregating 188,987·92ft. in length, of the area of ground photographed by the highest shots of the camera. These traverses were run with transit and tape and had an average error of closure of one part in 10,700. Following this survey the altitude was calculated by four different methods, as a result of which one photograph showed an altitude of 37,920ft. above ground, or 38,890ft. above sea level, and another photograph, made several minutes later in flight, showed an altitude of 38,080ft. above the ground, or 39,050ft. above sea level. The ground elevation of 970ft. was determined from the records of survey of the C.C.C. and St. L. Railroad which passes Rushville, Indiana. It is believed that these values for elevation, as determined through weeks of careful calculations, are correct to within 40ft. plus or minus.

IN a paper which he recently contributed to the Society of Engineers, Mr. F. H. Mackintosh described a rig of gear which he had devised for making test bore-holes in the ground single-handed. With this rig, he said, it was possible to carry enough rods to make trial holes up to 48ft. deep, in a golf bag. In explanation of the origin of his apparatus, Mr. Mackintosh said that in his experience the logs of boreholes are usually most untrustworthy records. This remark applies not only to the logs of bores several thousand feet in depth, but also to the shallow variety, usually known as trial holes, which are made for the purpose of proving ground for engineering projects, and, if anything, these latter are distinctly the worst. This is due probably to the close detail required in shallow holes which only penetrate the upper strata, a similar degree of accuracy not being so necessary when a thousand foot hole, or deeper, is concerned. But the main reason for this untrustworthiness is the fact that few, if any, drillers have more than a superficial knowledge of geology.

AN investigation of some of the various processes proposed for the utilisation of greensands, of which there are very large deposits along the Atlantic seaboard of America, is in progress at the Non-metallic Minerals Station, of the United States Bureau of Mines, at New Brunswick, New Jersey. A bibliography of the literature on greensands has been completed, and will be published in the near future. An economic survey of some of the proposed processes is also in course of preparation. In the laboratory experiments have been in progress for about two months on the so-called Charlton-Shreve process, involving the digestion of greensands with slaked lime at 200 deg. Cent. The results of these experiments may be briefly summarised as follows:—Digestion for two hours of 1 part greensand with 0·9 parts of lime, and 5·0 parts of water at 200 deg. Cent. and 225 lb. pressure in an autoclave resulted in 55 per cent. of the potash being rendered soluble. Digestion for four hours rendered soluble 67 per cent. of the potash. The greensand used contained 6·5 per cent. potash, and was ground as fine as is possible in a small ball mill. These results agree reasonably well with those of previous investigators.

IN an article in the Industrial Gas Supplement of the *Gas World*, which deals, among other things, with the galvanising of ship's plates, Mr. A. Docking points out that zinc is one of the most difficult metals to deal with when in a molten state, and must not at any time be subjected to a heat much above the critical working temperature. If the temperature is unduly raised in any spot, excessive dross is immediately formed, and there is at the same time a grave danger of overheating the bath, causing a leak at this particular spot. If such a thing happens, the tank is destroyed, as it is of no further use. It is, therefore, imperative that the temperature should be constant at all times, that the heat should be uniform all round the tank, and that the flame should be as soft as possible. The working temperature is about 830 deg. Fah., and it should be kept as near that as possible. Therefore, the most important things to consider in the heating of these tanks are:—(1) A soft flame that will not damage the tank; (2) a uniform heat all round the tank; (3) provision for the removal of the brickwork quickly, in case of a leak, so that it can be temporarily plugged; (4) thermostatic control of temperature.

Miscellanea.

IT is proposed to construct a five-storeyed motor garage in Durban, South Africa, at a cost of some £51,000.

THE Glasgow Corporation proposes to install a new 18,750 kW turbo-alternator in its Pinkstone Power Station.

IT is estimated that the cost of the water purification plant which the Ottawa Municipality proposes to install will be some 1,315,000 dollars.

IT is intended that the new nickel smelting plant of the International Nickel Company at Copper Cliff, Ontario, should be in running order by July next.

THE Newcastle and Gateshead Gas Company recently entered into an arrangement to take a quantity of gas from the new coke ovens just completed by the Consett Iron Company, Ltd., at Derwenthaugh.

WORK is being pressed forward on the tungsten-bearing ores discovered near Riverport, Nova Scotia. It is said that at depths of from 30ft. to 40ft. free gold has also been discovered in connection with the tungsten ore.

AN experimental retort, having a capacity of 50 tons a day, is being installed at New Glasgow, Nova Scotia, for the purpose of distilling the local shale. It is intended to increase the equipment so that from two to three hundred tons of shale can be treated daily. The shale beds are at a place called Steve Brookes.

IN view of the extending length of the British Industries Fair buildings at Castle Bromwich, Birmingham, it has been decided to institute a service of petrol-driven cars to provide free transport for visitors alongside the buildings on the south side. It is hardly necessary to reiterate the fact that the Fair opens on February 18th for a period of a fortnight.

A NEW lighthouse has been completed at Puerto Cabezas, on the Bragman Bluff section of the Nicaraguan Atlantic coast, at 14° 1′ 12″ N. latitude and 83° 23′ 15″ W. longitude. The lighthouse consists of a steel tower surmounted by a 1000-watt electric light with the centre of the beam 168ft. above sea level. The light, which has 6,000,000 candle-power, moves its beam over a sector of 180° towards S. 68° 30′ E., and is visible in clear weather for fourteen sea miles.

THE bridge which is being built on the Watford by-pass road over the L.M.S. Railway near Selvage-lane, Mill Hill, is an interesting engineering task. In order that there may be no obstruction to railway traffic whilst the work is proceeding, the two spans over the existing track are to be built of pre-cast concrete units, each weighing many tons. When the supporting piers are completed the sections forming the main girders, together with the deck slabs, will be lifted and lowered into position as complete units.

A PLANT for the manufacture of reinforced concrete pipes by the Hume process is to be put up at Lourenço Marques, Portuguese East Africa. It is proposed, says the *South African Engineer*, to devote the profits made by the South African State from its Namaqualand diamond diggings venture to the construction of a major irrigation scheme, and it is believed that the project likely to be undertaken is one which entails passing the Vaal River waters into the Harts River Valley. The cost of this scheme is estimated at about three million sterling.

WITH a view to supervising and controlling the pumping installations in Government Institutions and giving expert advice to all municipal open waterworks in the province, the Government of Patna is, according to *Indian Engineering*, opening a mechanical division of the Public Health Engineering Branch with a mechanical engineer in charge. Another qualified engineer with a special staff is entrusted with the preparation of a drainage scheme for the University area and other Government areas in Patna City. As the appointment of a committee to advise the Government upon certain important questions concerning co-operative movement will involve expenditure of about Rs. 30,000, it is understood that the formation of the committee will be postponed until the Legislative Council sanctions the expenditure.

THE foggy weather which recently prevailed in Birmingham led to a marked increase in the demand for electricity. All previous "records" were broken on January 22nd, when the output from the power stations amounted to 1,750,000 kWh in the twenty-four hours. These figures represent an increase of 30 per cent. on the corresponding day of last year. At a recent meeting of the Electric Supply Committee it was reported that the sales of electricity during the December quarter showed an increase of 8·8 per cent. over the corresponding period of 1927. An additional 1063 consumers were coupled up to the mains during last month, representing 12,000 extra lights and about 3500 horse-power in power supplies. A number of satisfactory agreements for bulk supplies to works was also approved.

PLANS are in preparation for the erection of an important traffic bridge across the False Creek inlet in the city of Vancouver, to cost in the neighbourhood of 3,000,000 dollars. The Burrard-street bridge is one of the major projects in the plans of the city authorities, which contemplate the provision of services for an urban area of one million inhabitants. A double-deck bridge is contemplated, the lower deck of which will provide for railway traffic to the False Creek industrial areas, and the structure is intended to replace the Canadian Pacific Railway trestle bridge at present in use. According to preliminary proposals, the structure will cost 3,180,000 dollars, as compared with 2,650,000 dollars for a single-deck bridge. The Provincial Government has agreed to contribute 200,000 dollars towards the cost of the bridge and the Canadian Pacific Railway Company 100,000 dollars. The bridge will furnish direct access to the municipality of Point Grey, in Greater Vancouver, and to the University of British Columbia endowment lands, where, on the headland overlooking the Pacific, there is being built a university city which represents one of the most notable town-planning movements in Canada at the present time. The University Endowment Lands project embraces 2700 acres. When fully developed it is expected that close to 12,000,000 dollars will have been provided for the Provincial University.

TWO NEW STEAM RAIL CARS FOR OVERSEAS SERVICE

CAMMELL LAIRD AND CO., LTD., NOTTINGHAM, AND SENTINEL WAGGON WORKS, LTD., SHREWSBURY, ENGINEERS

(*For description see page* 156)

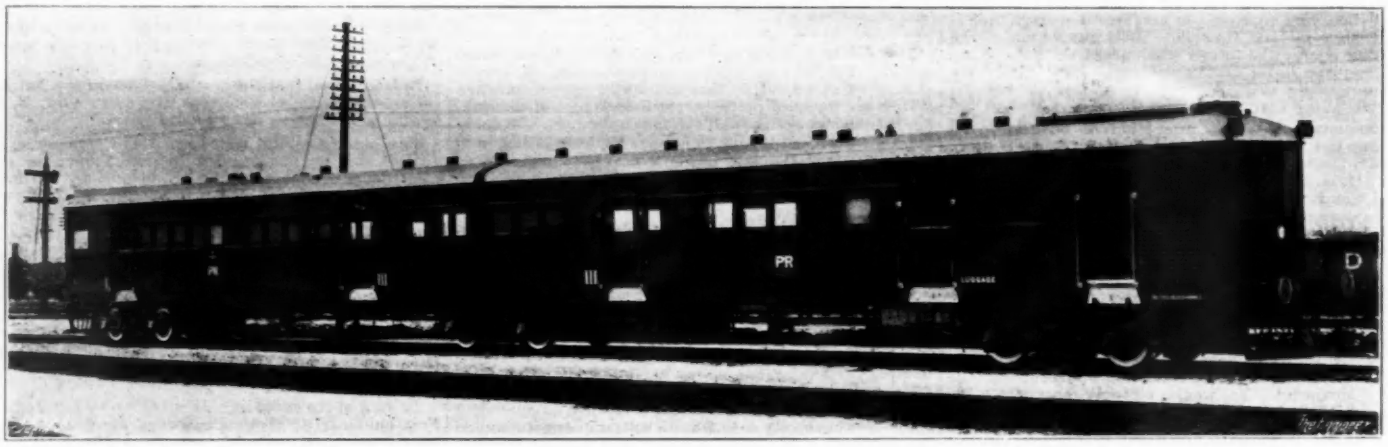


FIG. 1—DOUBLE ARTICULATED CAR FOR THE PALESTINE RAILWAYS

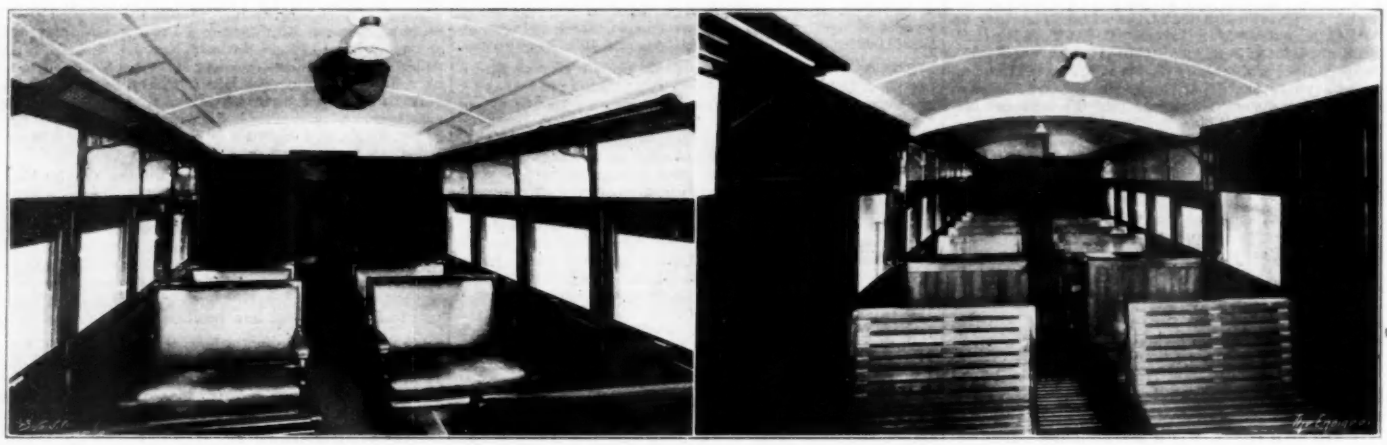


FIG. 2—FIRST-CLASS AND THIRD-CLASS COMPARTMENTS OF PALESTINE RAILWAYS CAR

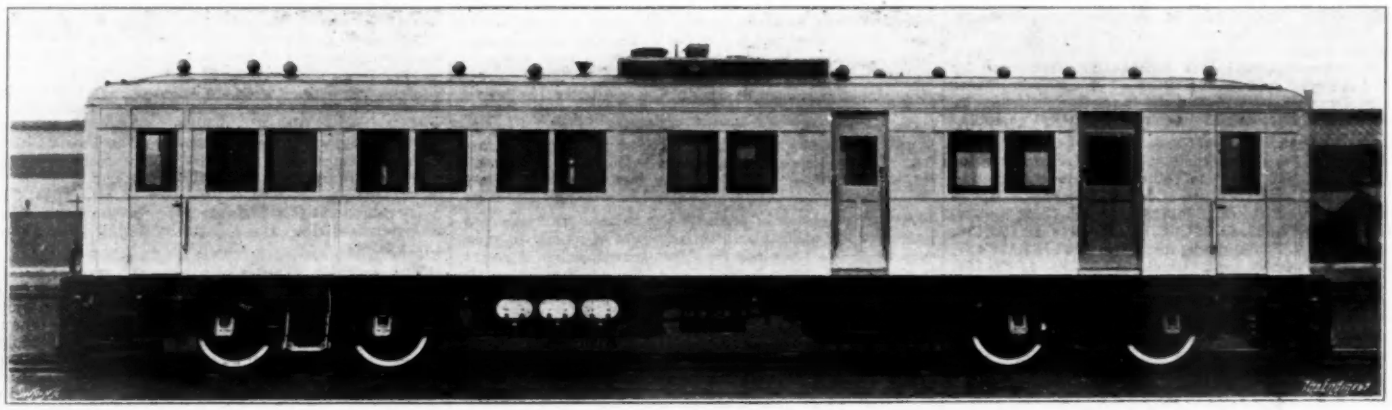


FIG. 3—INSPECTION CAR FOR THE LEOPOLDINA RAILWAY

FIG. 4—DRIVING, AND DAY COMPARTMENTS, AND CORRIDOR OF LEOPOLDINA RAILWAY CAR

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DEATHS.

ON February 6th, at Glasgow, JAMES RICHARDSON of William Beardmore and Co., Ltd., Naval Constructional Works, Dalmuir.

ON January 31st, suddenly, from pneumonia, following influenza, CHARLES CLARKE, joint managing director of Waygood-Otis, Ltd., in his fifty-ninth year.

THE ENGINEER.

FEBRUARY 8, 1929.

Modern Astronomy and the Engineer.

A YEAR ago Sir William Bragg, in the fourteenth Thomas Hawksley Lecture at the Institution of Mechanical Engineers, discussed the X-ray analysis of metals, and showed us something of the modern physicist's work on the investigation of atomic structure. It was highly fitting that the fifteenth Hawksley Lecture delivered last Friday by Professor Eddington should be devoted to a discussion of the machinery of the stars. Sir William Bragg, having taken us to one extreme outpost of science, Professor Eddington took us to the other. From a vision of the inconceivably small we were invited to pass to a contemplation of the inconceivably great. Alike, the two lectures demonstrated that Nature in her workshops and power-houses makes use of forces of which we, as engineers, have never dreamed, or of which, if within our ken, we have never appreciated the natural immensity. They almost numbed the mind with their revelation of the fields into which the physicist is now penetrating. They disclosed the engineer as a humble artizan in the mansion of science, endeavouring to apply the great forces of Nature with little or no understanding of what they are and what is their fundamental magnitude. Could we, as engineers, work on Nature's scale, we would have at our command temperatures of forty million degrees Centigrade, pressures reaching up to one and a-half million pounds per square inch, and velocities exceeding 180,000 miles an hour. We would find ourselves operating with bodies sixty thousand times as dense as water, with others behaving in a way which, if manifested in terrestrial substances, would lead us to conclude that they possessed negative specific heat and with yet others which simultaneously have the properties of a gas and those of a crystal. With such temperatures, pressures, velocities, and properties at his disposal, the engineer would find himself equipped to essay tasks beside which the greatest of his achievements so far would appear trifling.

From time immemorial man has been inclined to regard the accomplishments of his own age as marking the culmination of progress, discovery, and invention. To the Roman citizen at the height of the Empire's power, the world seemed very "modern," with its roads, bridges, aqueducts, central heating systems, hot baths, and postal services. The mid-Victorian, proud of the command obtained in his time by man over Nature, held it to be "to the last degree unlikely that as much progress would be made during the second half of the present century as marked its first fifty years." Less than a year ago Sir Alfred Ewing, in his James Forrest Lecture, taking stock of the inventions of the past century, expressed a doubt as to whether "the recent astounding pace" of discovery and progress could be maintained, and suggested that we were about to witness a lull in scientific developments and their practical application. Sir William Bragg and Professor Eddington have enabled us to see our position in this respect in a fuller light. They show us that if progress stops, it will not be because of the exhaustion of Nature's possibilities, but because of our inability to exploit them. With each fresh advance in astrophysics and in our knowledge concerning the atom and its structure, we see more and more clearly that man so far has scarcely begun to employ Nature's fundamental forces and processes. With each fresh advance the limits which Nature might impose on our progress recede farther and farther into the background. Progress in metallurgy or in any other art requiring the use of a high temperature will not be stopped because of an upper fundamental natural limit to temperature anywhere near the highest temperature so far reached by man. Downwards, as has long been known, Nature seems to set such a limit, but upwards the limit, if there is one, is at least 40,000,000 deg. Cent. If, however, the possibilities of Nature are virtually inexhaustible, it does not necessarily follow that we are so circumstanced as to take full advantage of them. The subatomic energy in a gramme of matter, we are told, represents a store of energy amounting to 9×10^{20} ergs, equivalent to the heat of combustion of about 3000 tons of coal. Nature makes use of this subatomic energy to maintain the heat of the sun and the luminous stars. A gramme of earthly matter contains an equal store of subatomic energy, but, in Professor Eddington's words, "it is a very remote dream that we shall ever be able to utilise it." The reason is apparently a fundamental one, the enunciation of which was perhaps the most striking and significant remark in the whole of Professor Eddington's lecture. On this "chilly little planet" we are presented with matter in an abnormal state and under abnormal conditions. Nine-tenths of the matter in the universe exists at a temperature of over a million degrees. The earthly material which the engineer handles, even though it be raised to the highest temperature of the electric furnace, is not in the normal condition in which Nature uses it. It would appear to be unlikely that we shall ever be able to make use of the subatomic energy, lying as it were at our feet, unless, perchance, we discover a means of "normalising" earthly matter and earthly conditions. On that point it is, however, impossible to speak with complete assurance. Many surprising developments in physics have yet doubtlessly to be made by earth-bound physicists. Sir Ernest Rutherford has already succeeded in artificially disintegrating the nuclei of some of the lighter elements, an achievement which, it is believed, surpasses the degree of atomic disruption which Nature can accomplish by means of the temperature existing in the stars. Even although that enormous temperature were essential for this or some other purpose, we have no grounds for believing that the ability to produce it lies beyond what man can realise. According to Professor Eddington, temperatures claimed to be of the order of 1,000,000 deg. Cent. have already been reached momentarily by Kapitza using intense magnetic fields. Such a temperature, though still far below that occurring in the interior of the sun and stars, exceeds the highest temperature ordinarily within man's reach by an amount which encourages us to believe that one day we may reproduce in the laboratory states and conditions equivalent to the normal found in Nature.

There is still much scepticism among practical people regarding the value to humanity of the work performed by the astrophysicist and his brother

at the opposite end of the scale, the atomist. There are still those who, appalled by the immensity or the minuteness of the measurements involved in these two branches of modern science, willingly allow their lack of understanding to turn to complete unbelief. It is admittedly difficult to adjust one's outlook from mundane figures to distances represented by 900,000 light years—the distance by which we are separated from the Andromeda nebula—to masses of $0{\cdot}9 \times 10^{-27}$ gramme—the mass of the electron—or to times such as 20 billion years—the length of time for which the store of energy in the sun will maintain it in existence at the present rate of radiation. But because these figures are difficult or impossible to comprehend we ought not to reject them either as unsound or ridiculous and of no value. They are the products of research as painstaking, skilled, and prolonged as anything undertaken in the name of engineering. Wrong they may be, subject to correction they probably are, but as engineers it does not become us to criticise them. That even the most transcendental of them is wholly valueless, we cannot quite believe. Astronomy and atomic physics lie at the extreme opposite ends of science, but just as the two ends of a straight line indefinitely produced meet at infinity, so, too, do these two branches of science merge into one another. In many of its problems, modern astronomy, as all who read Professor Eddington's discourse will perceive, makes very close contact with atomic physics. Conversely, atomic physics has already drawn heavily on astronomy for inspiration. It is possible that in its higher branches the study of astronomy will in the not distant future be pursued mainly for the light which it sheds on the problems of atomic structure. Only in the heavens does Nature provide us with visible means of directly observing many of the phenomena which on a minute scale are believed to be characteristic of the atom and its subdivisions.

Feed-water Research in America.

THE present fashion for "research" on a co-operative basis is as widespread in the United States as in Great Britain. There, as here, the leading engineering institutions interest themselves actively in the work, and though the Americans are without any State-aided bodies on the lines of our own trade research associations, they make up for the loss, such as it is, by an extraordinary energy in other ways. We have on several occasions referred to their concerted effort under the direction of the American Society of Mechanical Engineers to extend knowledge as to the properties of steam, but the problems connected with boiler feed water have called into being a far more formidable concourse of "researchers." By means of a "Joint Research Committee on Boiler Feed Water Studies," six national technical organisations are co-operating in a study of the various processes of purifying feed water. The bodies in question are the American Boiler Manufacturers' Association, the American Railway Engineering Association, the American Waterworks Association, the National Electric Light Association, the American Society for Testing Materials, and the American Society of Mechanical Engineers. The main committee is divided into no less than nine sub-committees, each of which is expected to submit a yearly report, and there is an executive committee, in addition, to act as a sort of general staff. According to a progress report of the executive committee, presented at the annual meeting of the A.S.M.E. last December, the researches in view are expected to cost £12,000 a year for five years, and until this sum is assured no active work is planned. It is hoped to receive half this amount from one of the larger engineering associations, though up to the date of the report it would seem that only £600 had been actually contributed by persons or companies interested in the work. A contribution, however, of £4000 a year for five years had been promised, contingent upon the rest of the money being found. There is, we imagine, little doubt that the Committee will eventually get the £60,000 or so for which it asks, for wealthy Americans seem ever ready to cast their surplus bread upon the waters of knowledge in the hope that someone may reap a harvest. Yet engineers familiar with English conditions may well be surprised at the inauguration of so expensive and comprehensive an investigation into the question of feed water, even if condenser circulating water is included, which seems to be the case. Possibly many Americans are surprised also, for the Executive Committee itself admits that considerable apathy exists in the engineering profession on certain phases of the problem of feed-water treatment. We hope we shall not be accused of want of sympathy with the Committee, or of apathy towards research in general, if we also admit a certain measure of surprise that enough work is to be found in connection with boiler feed water to keep it and its nine sub-committees busy for five years. In large modern power stations the problem is almost universally solved by the use of evaporators, about which there is surely little that remains to be discovered. In smaller plants, and especially where make-up water is of necessity considerable, softening by means of the lime-and-soda or the zeolite process is almost equally standard practice, and is equally well understood. In still smaller plants where soda or some mixture sold as a "boiler compound" is put into the feed water, the custom is not likely to be altered by all the research committees in the world. The trouble with feed water does not consist in ignorance as to suitable treatment, but rather in the continual supervision required to ensure that the treatment is properly carried out.

The report of the Executive Committee is followed by progress reports of four sub-committees. The sub-committee on "Zeolite Softeners, Internal Treatment, Priming, and Foaming," admits frankly that it is waiting for money with which it proposes to build an experimental boiler, in addition to carrying out experiments on commercial boilers. Its first objective is to find out some way of preventing the adherence of scale to the insides of boilers, and it hopes also to conduct comprehensive experiments to determine the causes and the best methods of preventing priming and foaming. All of these difficulties, with perhaps the partial exception of priming, arise from impure feed water, so that with proper attention to the feed-water treatment outside the boiler there would be nothing left for the Committee to do. It cannot be too much emphasised that a boiler is one of the most unsuitable appliances in existence for carrying out chemical processes. Its function is simply to make steam and every substance other than pure water which is allowed or caused to enter it can be a cause of infinite trouble. The higher the pressure and the severer the duty of a boiler, the more certainly will every substance, soluble or insoluble, which is not convertible into steam make its presence felt in some unpleasant fashion, so that the whole tendency of modern power station practice is to get away from medication in any shape or form and to feed the boilers with nothing but genuinely pure water. It would seem from the report of another sub-committee dealing with "Municipal Water Supplies, and the Effect of Trade Wastes in relation to the Use of Water in Power Plant Practice," that the pollution of streams is a much more serious problem in the United States than in this country. The Committee reports that heavy financial losses are being sustained by power plants owing to pollution of watercourses by trade effluents. The effect is shown in the corrosion and the increased operation and maintenance charges of boilers, condensers and other apparatus. Some of the statements made in the report as to river pollution seem to indicate a recklessness towards the interest of others which would never be tolerated here. The Committee makes no suggestion as to how power station engineers can protect their plant when confronted by gross pollution of their water supply. All that it can recommend is that action tending directly and indirectly to prevent pollution should be taken. Operating troubles caused by polluted water which have been brought directly to the notice of the Committee includes active corrosion of superheater tubes due to "volatile corrosive organic solids" in the water; foul condenser tubes, owing to oil in the circulating water; and prolific growths of algæ affecting water-purifying plants and condensers. These are not discussed at all, so that we are given no reason why the solids in the feed water could not be removed by filtration or precipitation, nor why the growths of algæ could not be prevented by the chlorination method which meets the difficulty perfectly in power stations here. Engineers in England have, certainly, no oilfields to contaminate their circulating water, but there is more than one large power station in the country which uses sewage effluent in its condensers without ill effects.

The sub-committee on Bibliography is a useful adjunct to such a large organisation engaged on so comprehensive a research, though of the four sub-committees which now report progress the one concerned with "Standard Methods of Water Analysis" would seem to have not the least useful task before it. No large power house can be properly run without very frequent tests of the water, whether it be feed, condensate, or the contents of the boiler drums. Such tests should be matters of every-day routine, and for this reason they ought to be so standardised that any careful young man can be trusted to carry them out. There is no great difference now between the methods of conducting the usual tests on water, but there is quite enough to make it worth while to have the best procedure codified by some competent body and adopted universally. The sub-committee on water analysis has so far confined itself to the single question of determining the oxygen in solution in feed water. For this purpose, it recommends provisionally the Winkler test, which is the one generally used, and proposes a list of standard reagents and apparatus, together with a method of using them. The proposals are now being carried out in the majority of the large power plants affiliated to the National Electric Light Association, with a view to determining the suitability of the details before the recommendation is made definitely. It is to be hoped that the sub-committee will turn its attention as soon as possible to the question of the permissible density of boiler water, and the degree of alkalinity which may be allowed without danger of embrittlement of the plates. The Boiler Code Committee of the A.S.M.E. has already issued recommendations in respect of alkalinity, but a thorough examination of the whole question and the promulgation of rules which, if followed, would set the minds of engineers at ease with respect to embrittlement, is badly needed.

New Fuel Research Laboratories at Ottawa.

By B. F. HAANEL.*

THE Department of Mines has erected in Ottawa a new Fuel Research Laboratory building, which is being equipped with modern large and small-scale apparatus for conducting extensive research on Canadian fuels—solid, liquid, and gaseous. The original building and equipment permitted of only large-scale tests with a view to determining the comparative values of solid fuels for the generation of steam and the production of a power and industrial gas. A small but well-equipped chemical laboratory was provided, and in it were made complete analyses of solid, liquid, and gaseous fuels, as well as determinations of the calorific powers of these fuels and an examination of their physical characteristics and properties. The work of the laboratories increased so rapidly that extensions to that building were made only a short time after its erection, and to-day these facilities have proven inadequate. It is hoped that the building now erected will serve the purpose of the Division of Fuels and Fuel Testing for some time.

The new laboratories were designed and the equipment selected with a view to carrying out investigations which would be in the interests of the development of the coal resources of the Dominion. The allocation of floor space will be as follows:—

BASEMENT.

Front Part:
- *a*, laboratory for small technical scale coal carbonisation, oil shale retorting and oil refining investigations.
- *b*, electric switchboards and gas meters.
- *c*, photomicrograph and photometer laboratory.
- *d*, receiving room and stores for chemical apparatus and chemicals.

Rear Part:
- *e*, gas engines.
- *f*, machine shop.
- *g*, coal grinding and sample preparation equipment.
- *h*, coal briquetting installation.
- *i*, coal washing equipment.
- *j*, stores.

A 2-ton by-product coke oven will be arranged outside at the rear of the building. The condensing and scrubbing train for the oven will be in the building on the ground floor. The minimum headroom in that part of the building occupied by the briquetting and coal washing equipment is 40ft., the maximum 60ft.

FIRST FLOOR.

Front Part:
- *a*, offices for executives and engineers.
- *b*, carbonisation laboratory for research and plant control.
- *c*, general gas analyses laboratory.

Rear Part (Technical Scale Laboratory):
- *d*, domestic furnaces for efficiency tests.
- *e*, powdered fuel boiler installation.
- *f*, gas producers.
- *g*, gas meters, scrubbers and condensers.
- *h*, space for low-temperature carbonisation retorts, coal liquefaction, &c.
- *i*, technical scale oil refining apparatus.

SECOND FLOOR (CHEMICAL LABORATORIES).

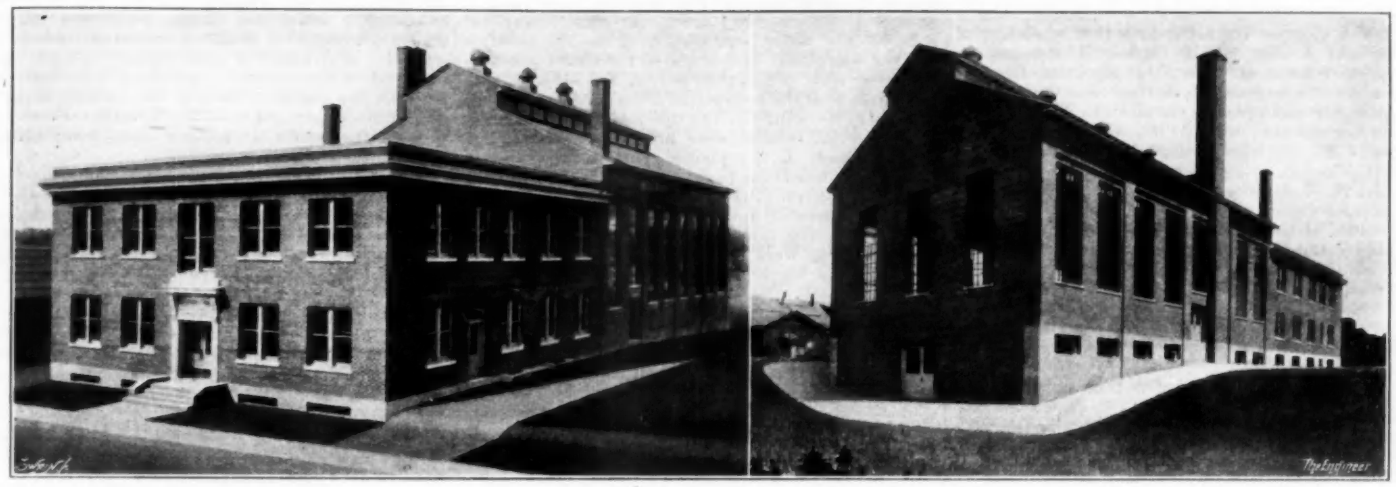
Front Part:

Solid fuel analysis:
- *a*, offices for engineering chemists.
- *b*, general laboratory (proximate analyses, &c.).
- *c*, calorimeter room.
- *d*, electric furnace room (ultimate analyses, &c.).

Liquid and gaseous fuels:
- *a*, offices for engineering and research chemists.
- *f*, general oil laboratory.
- *g*, oil research laboratory.
- *h*, gas research laboratory.

* Chief of the Division of Fuels and Fuel Testing, Ottawa.

NEW FUEL RESEARCH LABORATORIES AT OTTAWA



The permanent equipment, in addition to chemical laboratories and small-scale research apparatus, will include :—

(1) Commercial by-product recovery coke plant.
(2) Experimental domestic heating plant.
(3) Commercial scale powdered fuel steam generating plant.
(4) Commercial scale briquetting plant.
(5) Large-scale coal washing plant.

Commercial By-product Recovery Coke Plant.—The by-product recovery coke plant will have a capacity of 2 tons, and is of a type which is now being used commercially in the State of Illinois and elsewhere in the United States. This coke oven will be complete with gas condensing, scrubbing and recovery train and will enable the coking properties of coals to be determined in great detail. The coking of coals in this oven will furnish information regarding the physical properties of the cokes produced and allow the exact quantities of coke, tar oils, gas ammonium sulphate, light oils, &c., to be determined with accuracy. Before coals are coked in this oven small representative samples will be carbonised in the Koppers small-scale carbonisation apparatus, in which the conditions in a commercial type oven are approximated. The Koppers laboratory oven permits quantities of gas, tar oils, and other by-products, and also the yield of coke, to be determined, but the quality and physical properties of the coke which it is possible to make from any coal can be determined only in a large-scale oven. In the coking tests conducted in 1908 these properties were determined by coking coals in a perforated iron box which was placed in a coke oven with the regular charge. This method has been resorted to by the Division of Fuels and Fuel Testing in all large-scale coking tests, but has not proved altogether satisfactory.

Experimental Domestic Heating Plant.—The laboratory space allotted to the testing of domestic heaters will permit the erection of various types of domestic heaters now on the market, and also the testing out of alterations that it may be desirable to make to any type of heater, in order to burn a special class of coal more efficiently. The heating tests conducted during the past three or four years were confined to certain Canadian coals, coke, and imported coals. In the future these investigations will be extended to include fuel oil, retort gas and producer gas, as well as coals in the natural state.

Commercial Powdered Fuel Steam Generating Plant.—The burning of solid fuels in the pulverised form has assumed such great importance in recent years that it was decided to install complete equipment of this type, so that the comparative values of Canadian fuels for steam raising, when burned in the pulverised form, might be determined. Provision will be made for changes in burners, &c., to suit particular fuels. The burning of a solid fuel in the pulverised condition makes possible the utilisation of low-grade coals which cannot be satisfactorily burned by hand firing or on any mechanical stoker. It also permits considerable economies to be realised in operating costs when high-grade and more expensive fuels are burned.

Commercial Scale Briquetting Plant.—The commercial scale briquetting plant will be equipped with two types of presses—roll and plunger—and all necessary equipment, such as crushers, fluxors, macerators, &c. This plant will permit various briquetting processes to be tried out on a commercial scale, as well as on a technical scale, to determine the value of various types of binders and methods of treatment, heat and otherwise. Reliable information regarding the amenability of Canadian coals to any of the existing briquetting processes is very meagre, and the information which will be obtained in this manner will serve to guide those who are looking towards briquetting as a means of utilising coals.

Large-scale Coal Washing Plant.—Commercial scale dry and wet coal washing units will be installed. These will be utilised for determining the economy of submitting coals high in ash and sulphur to such treatment, and the degree to which they can be beneficiated.

Low-temperature Carbonisation Retorts.—The advantages claimed for processes for carbonising coals at low temperature are being brought so forcibly to the attention of the public that one of the important functions of a fuel research laboratory will be to secure reliable information concerning the value of low-temperature carbonisation when applied to any particular Canadian coal. The permanent equipment of the plant will consist of only one or two technical scale retorts constructed on two of the main systems, *e.g.*, internally and externally heated. It is proposed as the occasion arises to erect technical scale low-temperature carbonisation retorts of different types, with a capacity of from 500 lb. to 1000 lb. of fuel per day and with which it will be possible to demonstrate the soundness of the principles involved in design and construction. The most promising of the low-temperature carbonisation processes will be tested in this manner. The gas condensing, scrubbing, and recovery train, which will form a permanent part of the equipment of the laboratory, will serve these temporary experimental retorts, as well as the by-product recovery coke oven above mentioned.

Oil Cracking and Refining Plant.—Technical scale pressure cracking stills will be erected, and with this equipment, processes for treating oils will be investigated. The oils to be investigated will include those recovered in the carbonisation of coals, from oil shales, and from bituminous sands, and those obtained by synthetic liquid fuel or coal liquefaction processes. The results obtained will afford information regarding the value of the processes investigated for converting any of the above fuels into motor oils, lubricating oils, waxes, fuel oils, &c.

Liquefaction of Coal and the Production of Motor Spirits According to Synthetic Fuel Processes.—The main testing laboratory has been designed with sufficient floor space to permit of the erection of a coal liquefaction plant of modern capacity and apparatus for testing certain of the more promising synthetic liquid fuel processes, and it is hoped that such a plant will be installed in the near future.

Oil Shale Retorts.—The more promising of the processes for distilling oil shales will be tried out on a technical scale, using temporary retorts constructed according to different designs. In this manner oil shales obtained from the provinces of Nova Scotia, New Brunswick, and elsewhere in Canada will be tested.

Chemical Laboratories.—The main laboratories will contain the usual standard apparatus found in any well-equipped laboratories. Most of this equipment is already in use in the present fuel research station, but certain of the laboratory scale apparatus for conducting research relating to high and low-temperature carbonisation, synthetic fuel processes, and the cracking and refining of oils will be changed from time to time as required.

Literature.

Electrical Sub-stations. By H. BRAZIL. London : Edward Arnold and Co. Price 12s. net.

IN these days the supply of electricity to consumers involves the provision of sub-stations for reducing the pressure of the current as generated, and in some instances also for turning the three-phase current into direct current. Many early generating stations situated in cities and towns have been converted into sub-stations, which are fed from large and modern generating stations, situated in more favourable parts. The practice of generating low-pressure direct current has given place to high-pressure three-phase generation, and, in the interests of economy, the bulk of consumers are supplied with alternating current at suitable pressure. Where, however, a direct-current distribution system already exists, the cost of changing over to a three-phase, four-wire system is often prohibitive, and, in addition to reducing the pressure delivered to the sub-stations, it is also necessary to convert the alternating current into direct current by means of motor converters, rotary converters or rectifiers. There are, thus, two distinct types of sub-stations—those simply equipped with transformers, and those containing rotary machines or rectifiers.

In the present volume Mr. Brazil, who is connected with the Charing Cross Company, deals with both types of sub-station and describes in detail the plant which they contain. As far as we know, there is no other book published in this country that covers the same ground, although there are, of course, volumes that deal with sub-station equipment, such as converters, rectifiers and switchgear. Needless to say, automatic and supervisory control systems, which have made considerable progress in this country within recent years, are dealt with, and the author has acted wisely in omitting the complicated wiring diagrams often used to describe the operation of these systems. Throughout the book all the diagrams are quite simple and fairly easy to understand. The main fault we have to find with the author is that he seems a little inclined to support direct-current distribution, which, as Sir John Snell has shown conclusively, is undesirable from a commercial point of view. There are now few classes of service for which 50-cycle alternating current is not suitable, and the few consumers who must have direct current can in these days obtain it by installing rectifiers on their own premises. In their paper before the Institution of Electrical Engineers in 1926, Messrs. Beard and Haldane, who the author in several places quotes, drew attention to the desirability of making the three-phase four-wire system, with a voltage of 400 between phases and 230 between phases and neutral, standard, and showed that the expensive converting plant required with the direct-current system appreciably increased the cost of distribution. The question of superimposing an alternating-current distribution system on existing direct-current systems does not, in our opinion, receive the attention it deserves in this country, where, apart from other considerations, the task of finding sites for sub-stations to contain rotary machinery is not always an easy one. As we have indicated, however, the book should prove of considerable value to those interested in the design and operation of sub-stations, for it contains a large amount of information concerning converting plant, switchgear and other apparatus.

BOOKS RECEIVED.

Strength of Materials. By J. O. Draffin, M.S. London : Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 15s. net.

Omnibus Lighting and Starting. By J. W. Houghton, A.M.I.E.E. London : The Fanfare Press, 112, St. Martin's-lane, W.C. 2.

Practical Steel Making. By Walter Lister. London : Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 25s. net.

Forty-first Annual Report of the Incorporated Swansea Exchange, 1927–28. Swansea : The Royal Metal Exchange. Price 3s. 6d. net.

Underground Cable Systems. By G. W. Stubbings. London : Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 15s. net.

Principles of Underdrainage. By R. D. Walker. London : Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 15s. net.

Report on the Proposed Heightening of the Aswan Dam.

WITH a view to inquiring into the feasibility of raising the Aswan dam in order to impound an additional volume of water, the Egyptian Government appointed an international technical Commission to investigate and report on the matter. The members of the Commission were:—Mr. W. J. E. Binnie, M. Inst. C.E., as representing Great Britain; Mr. Hugh L. Cooper, as representing the United States; and Dr. H. E. Grüner, as representing Switzerland. The Commissioners arrived at the site of the Dam in the middle of last November, and so expeditiously did they carry out their work that their report was made public last week.

Although no printed copies of the Report are as yet obtainable in this country, we are enabled by the courtesy of Mr. Binnie, to put before our readers the following *précis* of the contents of the document.

Four References were put before the Commissioners. They were as follows:—

Reference No. 1. Whether in view of the past history of the Dam* and its paramount importance to Egypt, it is advisable to heighten the existing structure to the levels required, *i.e.*, to impound water to R.L. 120·00?

Reference No. 2. Whether any of the designs submitted are suitable as a means of carrying out the work, and, if so, which design they would recommend?

The Commissioners are requested to suggest any modifications to the selected design which, in their opinion, would make it more suitable.

Reference No. 3. In the event of none of the designs being acceptable, the Commissioners are requested to formulate their own proposals for the heightening.

Reference No. 4. The Minister of Public Works has also received proposals for various hydro-electric schemes to utilise the power which will be available at Aswan. These schemes usually involve alterations in the dam structure by piercing the solid portion of the dam and by modifying the existing culverts, and the Commissioners in recommending a design for heightening are requested to advise: "To what extent proposals on the above lines are compatible with the safety of the raised structure?"

REFERENCE NO. 1.

With regard to the first Reference the Commissioners state that their first work was to inspect the upstream face of the dam with the object of noting the appearance and extent of the cracks in it. They remark that, in a piece of masonry of such magnitude, there must be cracks, because it works under such different stresses, and a block of masonry is not an elastic, but a rigid body. All cracks, it is reported, were examined and noted. During the first few days of their stay at Aswan the upstream face of the structure was free of water, and could be examined thoroughly down to the level of R.L. 95·00. Later, one section of the sluices after another was closed, and at the end of their inspection the water level in the pool was at R.L. 104, so that the influence of the heightened water level on the dam could also be seen. In the upstream face thirty-six minor vertical cracks were noted. Those starting from an arch in the pierced portion of the dam extended upwards for from one to six courses, while those starting from the bottom of the solid portion of the dam extended upwards for a maximum of ten courses. In the downstream face some 175 small vertical cracks were noted in the pierced section of the dam, and about twenty-seven vertical cracks in the solid portion. "The vertical cracks in the pierced section all originate," states the Report, "in the crown of the sluiceway arches and extend upwards more or less vertically for distances of about 3 m., with the exception of those which had formed at the re-entrant angles of the buttresses which could be traced to R.L. 109. Some of these cracks were only surface cracks, and others were traceable as far back as the joint between the old and the new work. These cracks were never more than 1½ mm. in width at the time of our visit, and for the most part of their length they should be termed hair cracks. . . . In the solid section of the dam the cracks have been water bearing in several places, but the amount of this discharge has now become imperceptible even in times of winter temperature. While the cracks in the downstream face have been practically free from leakage, there are many places on the downstream face of the dam where very small discharges of water have occurred at isolated places, showing conclusively that the existing work is permeable, and permits the travel of water in voids and invisible cracks in the existing masonry."

Having dealt with the cracks on the upstream and downstream faces, the Commissioners then turned their attention to the condition of the 180 sluice culverts. They were particularly concerned, they state, (*a*) about erosion of these culverts and the condition of their gates; (*b*) about evidence of leakage into the sluice culverts from the pool; and (*c*) were especially careful to observe the physical condition of the inclined joint between the original dam and the heightened portion, so that any relative movement between the two might be noted. With regard to erosion in the sluice culverts, "there is," states the Report, "none except in a few isolated points in the floor nearest the corners at the bottom of the gates." The Report proceeds to say, however, that all the sluice gates need repairs, and that, if the dam is heightened, all these gates should be rebuilt, and at the same time improvements in details should be made, especially in the direction of rendering them more water-tight and of taking steps to eliminate the chattering of the roller frames which now takes place. Furthermore, it is recommended that the sluice wells should be examined in detail and strengthened where necessary to withstand the increased water pressure.

As regards leakage through the vertical walls and the roof of the sluice culverts from the pool, there is, the Report adds, abundant evidence that very small amounts of water are finding their way through invisible cracks and unknown scattered voids in the masonry, and some of this leakage is also to be observed on the outside facework of the buttresses between the sluices. Some of the leakage appeared shortly after the water level was raised in the reservoir, showing that water can make its way freely through some of the cracks.

As the result of very careful independent investigation, the Commissioners satisfied themselves that in not a single instance was there found the slightest evidence of movement of the outside or new portion of the work independently of the old work, and they reached the unanimous conclusion that the plans of the late Sir Benjamin Baker to create an absolutely monolithic condition in the finished work had been proved to be successful after sixteen years' service.

The Commissioners finally made a careful examination of the aprons below the sluices, special attention being directed towards ascertaining whether or not any upward pressure was exerted from the pool above under the masonry. On this point also evidence was given by Sir Murdoch MacDonald, who was in attendance, and Mr. D. A. F. Watt, the Resident Engineer, who was also present. Their testimony was to the effect that no upward pressure exists under these aprons, and it was confirmed, say the Commissioners, by their own observations, though, they add, that it should be remembered that they had not the opportunity of examining those aprons when the reservoir was filled above R.L. 104·00.

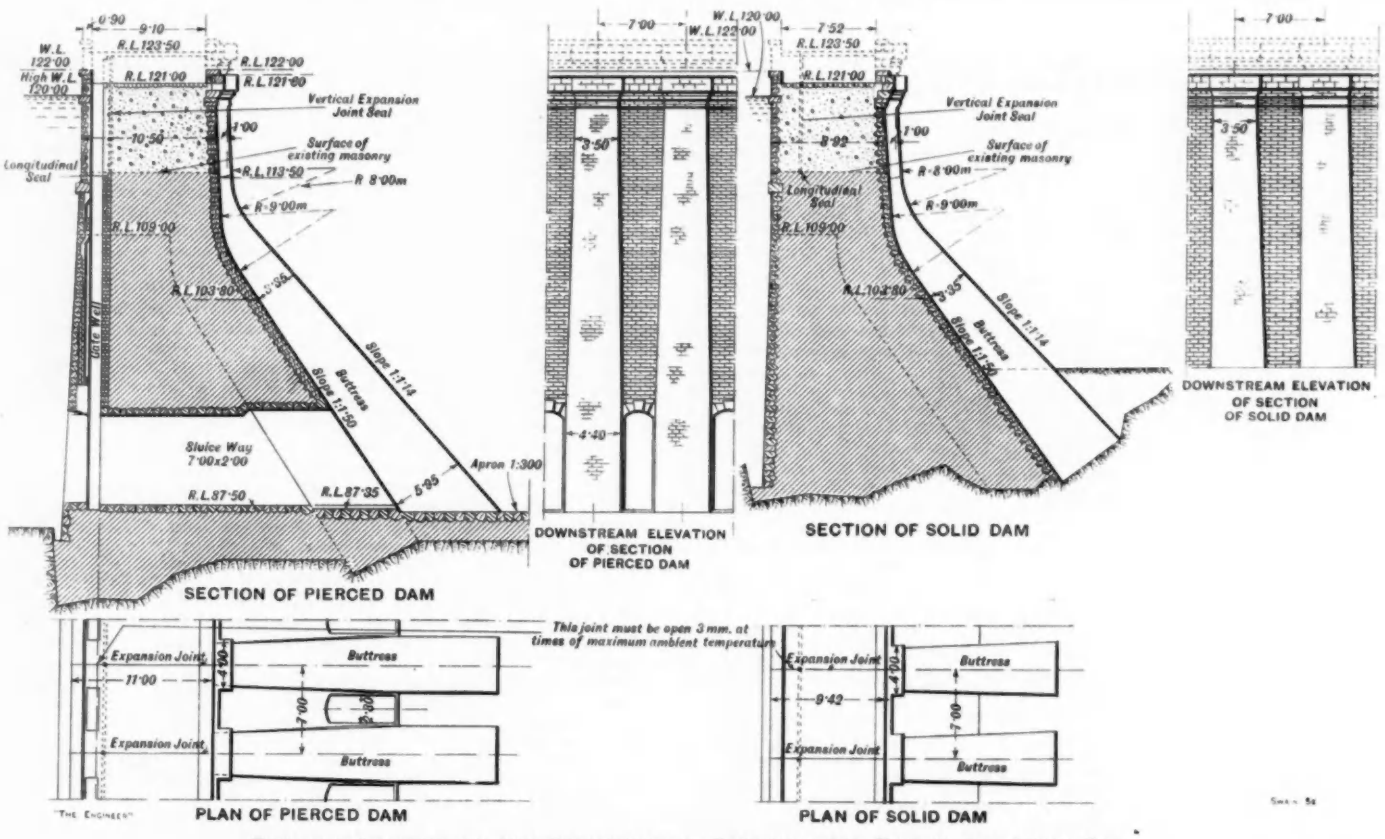
The observations made of the surfaces of the aprons—which, by the way, it was ascertained had needed no repairs since 1916—revealed a most excellent condition, and the Commissioners report that they are of opinion that the sluice culverts and their aprons can safely withstand velocities and volumes 50 per cent. in excess of those occurring in the past. It is recommended, however, that when the rock is cut out for the foundations of the new work for heightening the dam—to which reference is made later—careful examination should be made, with a full reservoir, to see whether water is passing under the foundations of the existing dam. If that is found to be the case, it is directed that holes should be drilled either at the water face or through the floor of the sluice culverts, and that Portland cement grout should be injected to destroy any uplift pressure.

The Commissioners state that, after an exhaustive individual and collective study of their observations, they have arrived at the conclusion that it is possible to heighten the dam as much as 9 m.—[say, 29ft. 6in.]—with entire safety.

In arriving at these conclusions, they have been guided by the following considerations:—

(1) That the rock on which the structure rests is capable of carrying a high compressive stress;

(2) That the masonry both of the original and the added structures has been well executed.



DRAWINGS ILLUSTRATING THE COMMISSIONERS' PROPOSALS FOR RAISING THE ASWAN DAM

* Our readers will remember that the dam has already been raised once, and that, at the time, there was a good deal of controversy regarding the stability of the structure.

[In other portions of the report the Commissioners aver that they were greatly impressed by the high quality of workmanship which could be observed and by the perfect condition in which the stone and pointing were seen];

(3) That there is no sign of fracture between the original dam and the portion subsequently added, so that the whole structure acts as a monolith;

(4) That the cracks are not of a nature to affect the stability of the existing structure; and

(5) That the toe of the dam is well protected against erosion by the existing aprons.

REFERENCE NO. II.

It is explained that five designs had been presented to the Commissioners for consideration. They were:—A scheme prepared by Sir Murdoch MacDonald and Partners; a scheme prepared by Professor L. Pottérat; and three alternative schemes put forward by the Director-General of Reservoirs.

For the consideration of these proposals the Commissioners formulated certain conditions, which, in their opinion, it was essential should be fulfilled by any work undertaken to heighten the dam. These conditions are as follows:—

(*a*) That it should be of such a design that all stresses are determinable;

(*b*) That the design should be such that no temperature stress would be transferred from the new to the old masonry;

(*c*) That the added part should, as far as possible, relieve the existing structure of stresses brought about by changes of temperature at the downstream face of the dam;

(*d*) That all stresses in the dam after heightening should be well below the requirements of conservative modern practice;

(*e*) That expansion joints should be provided to prevent the formation of cracks being brought about by changes of temperature;

(*f*) That the old masonry should remain in place and be disturbed as little as possible; and

(*g*) That the design should not detract from the architectural beauty of the present structure, but should, if possible, improve it.

After a careful study of all the five designs placed before them, the Commissioners decided that none of them complied with those conditions, although that prepared by Sir Murdoch MacDonald approximated most nearly to their fulfilment.

REFERENCE NO. III.

Having arrived at the conclusion that none of the five designs submitted was suitable, it became necessary for the Commissioners to formulate a design of their own. Their proposals, which are illustrated by means of drawings in the form of general plans—two of which are reproduced herewith—are briefly as follows:—

It is proposed that the vertical portion of the existing dam should be raised to the required height, the existing width of the roadway being retained, and that buttresses, varying in width, should be constructed on the downstream side between each sluice, the buttresses projecting from the existing structure for a distance of 6 m. at a level of R.L. 87·50, diminishing to 1 m. at the level of the existing roadway. The heightened portion of the dam would be slightly battered on the downstream face and provided with false buttress projections, so as to have the appearance of a continuance of the buttress below, a space being left between the two to allow of the expansion of the latter in a vertical direction. It is proposed that this horizontal joint should always be open at least 2 cm. at times of maximum ambient temperatures. The existing buttresses would each be strengthened by the addition of a new buttress of the same width conforming in all other particufars with those between the sluices. An asphalt key would be provided in order to prevent leakage of water at the plane of junction between the old and the new work.

The heightened portion would be divided into blocks, usually 7 m. in length by means of transverse joints provided with vertical keys to prevent leakage, these joints being arranged midway between the sluices in the pierced dam. By means of this articulation, allowance is made for expansion and contraction of the units of masonry without the formation of temperature cracks.

The proposed new buttresses are to have no fixed contact with the existing masonry, but are to rest on wrought iron non-corrosive bearing plates, 7 mm. thick. The design of buttress recommended requires the dressing down of the quarry faces of the existing masonry in the immediate paths of the buttresses for a width of 2 cm. on each side greater than the buttress width. This plan provides for the free movement of the buttresses in all directions during and after construction, without the possible development of destructive internal stresses in excess of the elastic limits of the material in use.

Stress is laid in the Report on the fact that the design submitted by the Commissioners requires almost no disturbance of existing masonry except the lifting of the roadway copings to the new adopted elevation and that the downstream face of the existing structure will be protected from the direct rays of the sun.

On the face of one of the drawings are some explanatory particulars which we reproduce verbatim:

GENERAL SPECIFICATION.

1. All buttresses shown on drawings 1, 2, 3 will be founded on solid rock or suitable apron masonry.

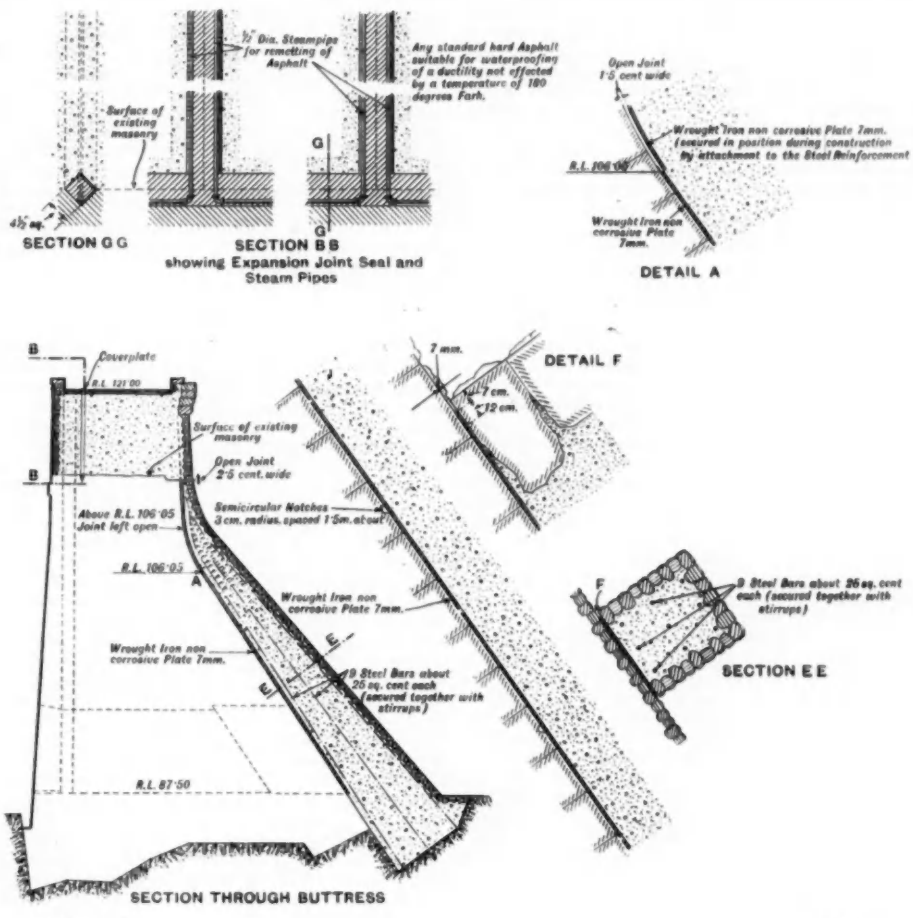
2. *Ashlar Masonry.*—All ashlar masonry will be of the class now in the downstream face of the dam, in every particular except as follows:—Where water discharged by sluices impinges on vertical faces of new buttresses, such faces will be of the quality of masonry in the walls of existing sluices.

3. *Joint Between New Buttresses and Existing Masonry.*—Existing masonry shall be dressed true to line to form a bed for a wrought iron non-corrosive joint bearing plate 7 mm. thick. The plates will be laid loose on their beds and close up edge to edge. No preservation will be applied to these bearing plates. The curved joint above R.L. 106·05 to R.L. 113·50 will be made by the use of a similar 7 mm. plate so fastened to the concrete as to produce a 15 mm. open joint as shown on drawing.

4. Reinforcing rods within the buttresses will be so used as to make an effective union between seasonal deposit of concrete.

5. All concrete will be of the best quality and each cubic metre will contain 250 kilos. of Portland cement.

6. The masonry above the existing work will be built complete in alternate sections. Sections first built will cure 120 days before intervening sections are filled in.



DETAILS OF PROPOSED NEW BUTTRESS

7. The masonry will be laid in mortar composed of one part of Portland cement to three parts of sand.

8. Before the masonry is laid the surface of the existing masonry will be thoroughly cleaned and washed.

9. Before the masonry is laid the surface of the existing masonry will be coated with a thin layer of cement grout.

10. The masonry will be laid in courses not exceeding 0·30 m. in height.

11. The masonry will be thoroughly bonded and will be laid in such a manner that no vertical joints will be formed.

12. The masonry will be kept wet for a period of 14 days after it is laid.

13. The masonry will be protected from the direct rays of the sun by means of awnings.

14. The masonry will be laid in such a manner that the temperature of the mortar will not exceed 15 deg. Cent.

15. The masonry will be laid in such a manner that the temperature of the mortar will not exceed 15 deg. Cent.

16. The masonry will be laid in such a manner that the temperature of the mortar will not exceed 15 deg. Cent.

Dam can be raised a second time and we are satisfied that this raising can be done without endangering the structure in any way, but at the same time we would like to state that a third raising of the Dam is impracticable, and it would therefore be better to make the second heightening such that the quantity of water impounded would assure the maximum possible supply to the river."

Engineering Principles in the Machinery of the Stars.*

By Professor A. S. EDDINGTON, M.A., D.Sc., LL.D., F.R.S.

Astronomy and Engineering.—The Council of the Institution of Mechanical Engineers has taken an unusual step in appointing an astronomer to deliver the Thomas Hawksley Lecture. Perhaps the closest relations between our respective sciences would be found in the problems of construction of telescopes, particularly in the monster telescopes that are now so essential to astronomical research. For these enterprises an astronomer ought also to be a skilful engineer, but I am not qualified in that way. I come as one ignorant of the subject who can only accept with gratitude these gifts of engineering to our science. I ought indeed to be rather a pariah among you, because much of my work has been devoted to that side of modern physics which is bent on destroying the mechanical basis of the universe and showing that ether and matter are not constructed as an engineer would have devised, but rest rather on those strange conceptions associated with relativity and the quantum theory. We have been busy wrecking mechanical models and driving out the engineer. Our predecessors thought of gravitation as a stress carried by an ether of rigidity greater than steel; if you inquire about gravitation now we put you off with talk about curvature of space. The electron used to have at least something concrete about it. A year or two ago it was set spinning, and we conjured up visions of fly-wheels; but now we have got rid of the suspicion of mechanical contrivance, and deal with it by the mathematical device of matrices. In short, Dame Nature is no longer a bustling engineer; she is a serene mathematician.

But however unmechanical her methods, Nature does contrive to produce engineering work on the grand scale, and my task must be to show you something of these achievements. Whilst not forgetting the title of this lecture, I think it would be unwise to let it cramp us unduly, or to force continually the parallel with engineering problems. We ought to see something of the general setting in which engineering principles with others play their part. In using the terms "engine" and "machinery" in connection with stars, I am not merely offering a bait to engineers. So far as my personal work on the interior of a star is concerned, it was an engineering problem viewed from an engineering standpoint which led me to take it up. I was attracted by the problem of the pulsating stars in which mechanical energy must constantly be supplied to maintain the pulsation against dissipative forces; and I approached it from the point of view that the interior of the star must be treated as a heat engine, and therefore subject to the familiar law of heat engines, namely, that in order to produce mechanical work, heat must be supplied to the working substance at a high temperature and withdrawn at a lower temperature. If there is one principle of physics which is pre-eminently the property of engineers, it is the second law of thermo-dynamics. That, as you know, is bound up with the theory of the heat engine; both its history and usage stamp it as essentially a development on the engineering side. Sometimes in astronomy we use it in a direct manner as in the problem of pulsating stars to which I have just referred. Sometimes we employ its remoter consequences. But in one form or another it has been the mainstay of astrophysical investigations, and I shall allude to it from time to time.

The Sun.—We may take the sun as a fairly typical star. The pressure at various depths in the sun can be calculated without much difficulty, just as the stresses in a pillar or wall are calculated. The pressure at the centre of the sun is between 10,000 million and 100,000 million atmospheres; that represents the accumulated weight of the long column of material stretching up to the surface which is pressing down on the material at the centre. The temperature is more difficult to calculate, and, indeed, until recently it was thought that the problem was soluble only for the so-called "giant" stars, which are much more rarefied than the sun. But we now realise that in stellar conditions matter remains a true gas even at very high densities, so that the simplifications appropriate for a perfect gas are admissible. The temperature at the centre of the sun is found to be 40,000,000 deg. Cent. It is a remarkable fact that our calculations give the same central temperature for the great majority of the stars. It would almost seem that there is some unknown peculiarity about a temperature of 40 million degrees; but I do not think any of the attempts to account for it can be regarded as satisfactory.

Effect of High Temperature.—In dealing with these high temperatures we have to recognise that a profound change has occurred in the state of matter. The atoms are broken up—or, in scientific terms, strongly ionised. We must be careful in using the phrase "broken up," because two quite distinct atomic processes may be so described. Taking, for example, an atom of iron, it is pictured as consisting of a small compact nucleus which contains nearly all the mass, together with a system of twenty-six satellite electrons, more or less remote from the nucleus. The nucleus is only a minute speck at the centre, and it is the system of satellite electrons which balloons out the atom to the dimensions that we ordinarily attribute to it. This system is disarranged and torn by the terrific commotion in the interior of a star, so much so that most of the iron atoms retain only two of their electrons which are held closer to the nucleus and more tightly than the others. The remaining twenty-four are loose and wander freely about in the material as though they were little atoms on their own. We should notice one point which will be important later. The big ballooning structure which gives volume to terrestrial atoms has disappeared in the star. All that is left is the nucleus with two close electrons, a structure occupying only a millionth of the volume of a terrestrial atom of iron. The twenty-four electrons when released from sentinel duty as outposts of the atom, take up practically no room as individuals.

This breaking up must not be confused with permanent transmutation of the atoms, such as occurs when radium disintegrates. However shattered the electron system may be, so long as the nucleus remains intact, the atom is still an iron atom. If the turmoil were stayed for an instant, *i.e.*, if the temperature dropped, each nucleus would seize the right number of free electrons and make its system of twenty-six complete. The material would become ordinary iron vapour again. If, however, the nucleus is broken, a permanent change is made in the nature of the atom, and it is no longer the same element. The temperature in the stars is, so far as we know, not high enough to produce breakage of the nucleus and its effects are limited to the outer electron system.

X-rays in the Interior.—Besides shattered atoms and free electrons rushing about tumultuously, there is something else in the star of great importance to its mechanism. Vast quantities of X-rays are present, travelling in all directions. We can picture the scene. Atoms tear along at 50 miles a second, having lost their voluminous clothing in the scrimmage. The free electrons torn from them are hastening a hundred times faster. Collisions occur in reckless profusion. After a thousand narrow shaves and side-slips, an electron is caught and begins to circulate round its captor; but barely has it settled down when an X-ray bears down on the atom and blasts the electron away again. And so it goes on, energy passing from ether to matter and back to ether. The ethereal energy leaks slowly through the star as through a sieve. If suddenly all the atoms and electrons of the sun vanished by a stroke of the magician's wand, the X-rays in the interior would scatter through space with the velocity of light; two million years' supply of radiant energy would be squandered in an instant. The atoms dam up this store, catching and turning back the ether waves as they try to escape, and only a slight leakage dribbles out to illuminate and warm the earth and other planets.

We infer the existence of these X-rays inside the stars simply from the second law of thermo-dynamics, and we calculate their quantity and intensity from the same law. We simply apply in the interior of a star the well-known rule that an engine working between two given temperatures cannot develop more than a certain maximum efficiency. If we are wrong, then it will be possible to make an engine worked by X-rays which has a greater efficiency than is allowed by the rule—a contingency which we are convinced is impossible. There are two stages. By a very simple application we can prove that the amount and constitution of the radiant energy within any constant-temperature enclosure depends only on the temperature, and not at all on the material in the enclosure or its walls; by a much more elaborate mathematical application we deduce from our knowledge of the amount and constitution of the radiation at any one temperature its amount and constitution at any other temperature—Wien's Law. Thus, experiments at terrestrial temperatures are sufficient to teach us all about the nature of the radiation in material, even at 40,000,000 deg., provided only that we admit the universal validity of the law of heat engines.

I have spoken of the X-rays leaking outwards through the star. What actually emerge are, however, not X-rays, but light and heat rays. That requires a word of explanation. Perhaps it might be put this way: The stellar power station is equipped with transformers which step down the high-tension output of the main machines to a low-tension form for outside distribution. In the star the transformation is gradual. As they progress outwards, the X-rays gradually lengthen in wave length until they can no longer be classed as X-rays. But the last stage of the stepping down from X-rays to light rays occupies so small an outer shell of the star that we are not concerned to follow it in detail. Once we have traced the radiant flow up to the beginning of this shell, our work is really ended. It will all emerge somehow or other because there is too little material in the shell to plunder or reinforce the stream appreciably. The amount of outflow is determined by the temperature gradient and opacity in the interior. The outflow may change in character, but not in quantity, in passing through the outer shell. If these outside layers tried to check it they would be blown away. Actually, they adjust themselves so as to let it through.

Theoretical and Observed Output of Heat.—Having perhaps sufficiently indicated the general line of the calculations, we pass on to the comparison of the theoretical output and the observed output of the stellar power station. You will recall that we have not been dealing with the question of fuel supply. The heat is supplied in the deep interior, we do not particularly mind how. We deal only with the manner in which the star regulates its passage into outer space. Our problem may be compared with a calculation of water supply from the pressure and diameter of the mains, which does not involve any discussion of the problems of the pumping station. We find first that the output depends on the mass of the star. Rather surprisingly it does not depend to any important extent on the density—whether the mass is diffused into a large volume or concentrated in a small volume—but it is assumed that the density is not too great for the material to behave as a perfect gas.

The sun is generally regarded as a typical star; and, indeed, it is just about as ordinary a star as you could find. But the stars have great variety and range widely on either side of this type. About fifteen years ago it was realised that some stars were enormously swollen in bulk. Not containing much more material than the sun, they nevertheless fill a thousand or a million times the volume. The well-known star Betelgeuse is so great that the whole orbit of the earth could be put inside it, and its density is so low that it corresponds to that of a fairly good vacuum. Capella has a mean density about equal to air, and many other examples of these bloated "giant stars" are known. Stars of density equal to or below that of air may evidently be treated as perfect gas, and should agree with the curve calculated for a perfect gas; but the surprising thing is that these are not the only stars that fit the curve. The sun has a mean density greater than water, but it is very near the curve. Other stars have the density of iron or lead; they also fit, or if they deviate at all it is on the superperfect side. As soon as the diagram called attention to this behaviour, the explanation suggested itself. A gas ceases to be perfect when it has been compressed so much that its atoms begin to jam in contact, or when the volume actually occupied by the atoms is a considerable fraction of the whole volume of the gas. But we have already seen that the structure which swells out the volume of a terrestrial atom is broken up in the star. The tiny fragments which survive will not jam at any ordinary density. The breaking-up of atoms at temperatures of the order of 10,000,000 deg. has the effect that stellar material of the density of water or even of platinum is still a true gas.

Matter of High Density.—In saying that material as dense as platinum is, under stellar conditions, a perfect gas, I mean that it still has the characteristic compressibility of a gas, namely, that if you double the pressure you halve the volume. There is nothing to prevent advantage being taken of this compressibility, so that the density need not stop at that of platinum. Under sufficient pressure a density may be reached far transcending anything known to us on the earth. There is no limit to the compressibility until the tiny fragments of atoms begin to jam, and that will not happen until we reach densities something like 100,000 times greater than those of terrestrial liquids and solids. There are two or three stars known to us which are believed actually to possess enormous densities which a few years ago seemed incredible. They are called "white dwarfs." They are intrinsically faint, giving out much less light than the sun; and yet the white colour of their light and the character of their spectra show that their surfaces must be at high temperature glowing very brilliantly. The surface is brilliant though the total light is small. This combination can only be accounted for by supposing that they are small objects. The mass or total amount of matter is found to be much the same as that of the sun; and since this has to be packed into a much smaller globe, the resulting density is enormous. The best known of these stars is the Companion of Sirius—a faint star which first betrayed itself because it was noticed that Sirius was moving irregularly as if under the attraction of an unseen mass. Like Neptune, its influence was perceived long before it was actually seen. However, it is now visible in large telescopes and can be fully examined. The density is found to be 60,000 times that of water. A ton of its material would go inside a match-box.

Dense material such as I have been describing must appear to us at first almost as an incredible fairy tale. But I am sure we are looking at it from the wrong attitude. You terrestrial engineers are concerned with matter in a very abnormal state. Nine-tenths of the matter of the universe—at any rate, of the matter that we are directly aware of—is tucked away in the interior of stars under temperatures of more than a million degrees. That is the normal condition of matter and we must not take our experience of matter on this chilly little planet as at all typical.

Crystalline Gas.—Those who are curious as to the

* The Institution of Mechanical Engineers. The Fifteenth Thomas Hawksley Lecture. Friday, February 1st, 1929.

possible states of matter may be interested to know that the problem of the stellar interior leads us to consider a rather remarkable state, namely, a crystalline gas. I do not think the gas inside a star is crystalline, but it is not so far removed from that condition that we can leave the possibility out of all consideration; and, at any rate, material which is at the same time a crystal and a true gas seems to be possible under the right conditions.

Pulsating Stars.—I come now to pulsating stars. The variable star δ Cephei is a typical example. It is a rather large star, probably about ten times as massive as the sun, and it is in a diffuse condition with an average density less than that of air. This globe swells and contracts periodically, so that the volume at maximum is about 20 per cent. greater than the volume at minimum. The variation has gone on regularly with a period of 5⅓ days ever since the star was first observed 150 years ago. During the contraction the inner material is being compressed and consequently rises in temperature. The adiabatic law will apply very approximately because the whole process is on so vast a scale that heat leakages are relatively small. During expansion there will similarly be an adiabatic cooling. Owing to these changes of internal temperature the outward flow of heat varies periodically and the brightness of the star waxes and wanes in the period of 5⅓ days. It is this varying brightness which calls our attention to stars of this class.

This phenomenon immediately provokes the question, How is the pulsation maintained? If there were no energy to renew it, the vibration would gradually dissipate itself. The decay would not be very rapid and I do not think it would be noticeable in the 150 years during which we have been watching the star, but there would certainly be a considerable falling off in the course of 10,000 years. Ten thousand years is a mere nothing in the long life of a star; and the fact that we find a large number of stars in this condition shows that it is not merely a transitory incident. We must look for some mechanism by which, as a star reaches a certain phase of evolution, a pulsation is started up and maintained for a long while. It will die down again when the star has evolved further, and reached a condition no longer favourable for pulsation.

There is no immediate difficulty about finding the required energy. We are bound to suppose that from some source or other heat is being liberated in the interior of the star to keep up the stream of radiation emitted into space. If only a small part of this can be diverted for use in starting or maintaining the mechanical energy of pulsation, it will be quite adequate. But we must here apply the principle of the heat engine. Mechanical work is only obtained from heat if there is a "working substance" taking up heat at a high temperature, and giving out heat at a low temperature. Accordingly, some part of the star must behave as a thermo-dynamic engine, converting heat into work according to the above condition.

Generally speaking, it is in the nature of things to acquire heat from their surroundings more readily when they are at a low temperature than at a high temperature—the wrong phase for a thermo-dynamic engine. That is to say, the natural tendency is to dissipate mechanical work, not to produce it. The engineer overcomes this by the use of valves, which artificially control the flow of heat. In the star the "valve" which controls flow of heat from one part of a star to another is the opacity—the obstruction to X-rays which constitute the more mobile part of the heat. The opacity depends on temperature and density, and therefore alters in the course of the pulsation. When it decreases, the effect is like opening a valve. We are therefore faced with the problem of determining which way the valve mechanism in the interior of a star is operating. Is the phase such as to admit heat into any region at the right moment and let it out at the right moment? Using the general laws of opacity so far as they are known, we have worked out this problem and the conclusion is adverse. The valves open and close at the wrong time, and increase the dissipation instead of setting the engine going. But when you come to think of it, that result is not so bad after all. Cepheid variables are the exception, not the rule; and it would have been disastrous if we had proved that the normal conditions in a star are such that the slightest provocation will start up its engine and set it pulsating.

There is another possibility which seems much simpler, but I am afraid there are grave objections to it. We believe that the heat of a star is replenished from some sub-atomic store of energy. Instead of worrying about the flow of heat from one part of a star to another, we can study the "valve" which regulates the supply of heat from this store. All we have to arrange is that the tap of sub-atomic energy shall be turned on fully when the material of the star is hottest—at the time of greatest compression—and closed when it is coldest—at the time of greatest extension. Then the star will behave as a heat engine working between these two temperatures and converting heat into work with something like maximum efficiency. Although we have no experimental knowledge of the conditions of release of sub-atomic energy, it seems almost obvious that the turning on and off of a tap would occur in the way suggested. If temperature has any effect at all, it will presumably stimulate liberation of sub-atomic energy; and if more than one atom or electron is concerned in the liberation, the increased density at the time of greatest compression will accelerate the interaction. We thus arrive at the following view:—During the state of compression, the liberation of sub-atomic energy is stimulated by the higher temperature and density, and the star is gaining more heat than it loses by radiation. This heat gives greater vigour to the rebound from compression. During the next half-period of rarefaction, the star correspondingly suffers a net loss of heat, and this aids the ensuing return to compression. The pulsation is thus encouraged at each stage, so that a small pulsation will grow up to the greatest possible limits.

But once again we have to remind ourselves that the problem is not so much to explain why stars are able to pulsate, but rather to explain why stars, with comparatively few exceptions, do not pulsate. The problem of the Cepheids sinks to relative unimportance. We see that there is a more fundamental problem of stability of ordinary stars. The law of release of sub-atomic energy must be such that in general it does not upset the stability of stars. I cannot here enter into the intricacies of the problem. I will only mention one circumstance which makes it somewhat different from analogous problems in our terrestrial experience, namely, that a star has a negative specific heat.

Negative Specific Heat.—It is our usual experience that when a body loses heat, it gets colder. Nearly sixty years ago Homer Lane showed that a star behaves paradoxically, and when it loses heat it gets hotter. It is true the deception practised on us is rather transparent. It happens in this way. When a star loses heat—by squandering it in radiation, for example—the pressure in the interior is relaxed a little, so that the whole star contracts. But this contraction or falling in of material generates heat, converting gravitational energy into heat, and the generation of heat more than replaces the loss. The result is that internal temperature rises. Lane's Law was only asserted for gaseous stars. For liquid stars the contraction would no longer be great enough to replenish the heat radiated; but we now believe that all ordinary stars are perfectly gaseous, so that the law is general. If, then, we ask how much heat must be added to a star in order that its temperature may rise by 1 deg., the answer is that no heat must be added; heat must be taken away. As Professor H. N. Russell has put it, the specific heat is negative.

One further point may be mentioned before we leave the Cepheids. The stars differ from one another in two respects, namely, in mass and density. It appears that there is just one stage of evolution at which Cepheid pulsation is set up, so that for any given mass there is just one corresponding density which permits pulsation. Now the period of pulsation depends mainly on the density, being longest in the most diffuse stars. There is, in fact, excellent agreement between theory and observation as regards the periods. It follows that just one kind of star can have Cepheid pulsations of given period; and if we meet with a Cepheid variable of period 5⅓ days anywhere in the universe, it ought to be in all respects a replica of δ Cephei. This has been stringently tested by observation. There is a definite period-luminosity law, so that as soon as we know the period of a Cepheid variable, we can say at once what its absolute brightness must be. Fortunately, the Cepheid variables are among the most luminous of the stars, and they can be observed in the remotest parts of the universe; wherever we observe them, we have at once a gauge of distance. Results of the greatest interest have been found in this way by Hertzsprung, Shapley and Hubble, and our present idea of the scale of the universe is based almost wholly on this evidence. We have learnt that the famous star-cluster ω Centauri is 20,000 light years away, and that the light of the great Andromeda nebula which we are now receiving left it 900,000 years ago.

Fuel Supply of a Star.—The question of the fuel supply of a star is one which the astronomer finds it difficult to keep away from, although there is not very much progress to record. It seems clear that the stellar furnace must be stoked from inside, not from outside. The problem is not just to maintain the radiation from the surface, but to maintain the tremendous temperature in the interior which keeps the star distended to its actual size. Thus, it is no use supposing that the sun's heat is supplied by a bombardment of its surface with meteors; you cannot maintain a temperature gradient by supplying heat at the bottom end, and the bombardment would not prevent the heat flowing away from the interior. The source of stellar energy must supply heat in the deep interior.

The principal basis for discussion was supplied by Einstein, who showed the equivalence of mass and energy. A mass of 1 gramme represents an energy of 9×10^{20} ergs, and by the same proportion we at once find the total amount of energy contained in the sun or any other star of known mass. Accepting our conclusion that the heat cannot be supplied from outside, this calculation gives the total store of energy which the star can draw on to provide heat for the rest of its life. The store is ample for all reasonable demands, and it would suffice to maintain the sun's present radiation for 20 billion years. But the question arises whether any considerable proportion of it is actually utilisable. There is the same enormous store of sub-atomic energy in the material of this earth, but it is a very remote dream that we shall ever be able to utilise it.

Most of this energy is energy of constitution of the electrons and protons of which matter is built up. If it is released, the matter must disappear. It is as though something might slip in the structure of the world, and where we had previously a proton and electron we have now only an ether wave carrying off the released energy. Is such a slipping back possible? We can only speculate. But it is not at all an idle speculation, because our whole theory of stellar evolution turns on the answer. If this energy of constitution which forms 99 per cent. of the whole store is not being released, the corresponding 99 per cent. of the star's mass is permanent. It seems impossible that a star can lose mass by actual escape of material anything like so fast as it loses it by radiation. Hence the star will remain of practically constant mass until the fuel supply gives out and the star becomes dead. But if the energy of constitution is releasable, the star can gradually radiate away any proportion of its mass, and big stars will evolve into little stars. There is much observational evidence which favours the view that a star grows fainter and less massive as it grows old; and this is our main ground for accepting provisionally the hypothesis that a star's heat is provided by destruction of matter inside it. But, on the other hand, there are some observational results which are hard to reconcile with this. I have already referred to the difficulty of assigning laws controlling the rate of this—or any other—sub-atomic process, and the fact that the simpler theories must be rejected as making the star unstable.

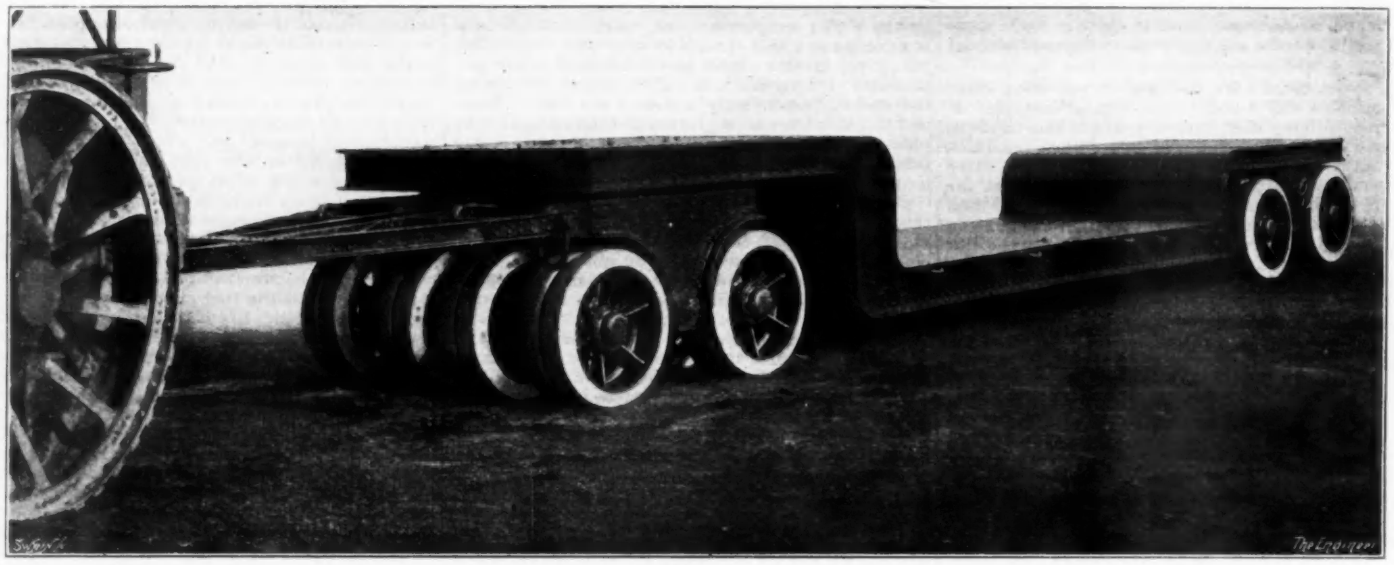
At present we seem to be back at the beginning of the problem of stellar evolution, scarcely able to make up our minds whether faint stars are evolved from bright stars or whether they were born bright and faint respectively. A biologist cannot have got far towards a satisfactory theory of evolution if he is still in the position of wondering whether puppies grow into dogs or whether dogs and puppies were born different. That is more or less our state to-day. Nevertheless, our feeling is not one of despair at the indefiniteness of present conclusions, but rather of interest and anticipation with regard to a great problem unfolding itself before us, which it seems possible to advance by many and varied lines of research. And if you should at some future date again select an astronomer to deliver this lecture, it is not unlikely that he will have much to tell of progress in the field of stellar evolution, coupled with a clearer understanding of those stores of energy held so fast and so tantalisingly within the atom.

SIXTY YEARS AGO.

SIXTY years ago the construction of the Union Pacific Railroad of America was exciting much interest, not only in the United States but in this country, and incidentally was providing the late Bret Harte with material for some of his best-known sketches and poems. Little authentic information was, however, available concerning the actual constructive work until we published a description of it in our issue of February 5th, 1869. The writer of our article had passed over the line as so far constructed, presumably in the preceding autumn. The work was being carried out by two companies, the Central Pacific Company which, starting at Sacramento in California, was pushing eastwards, and the Union Pacific Company, which was laying a track westwards from Omaha on the Missouri. The exact point at which the two sections were to join up was not specified. Each company was exerting itself to the utmost to make the junction as far eastwards or westwards respectively, as it could in order to secure a proportionately great share of the traffic receipts, and, in addition, in order that it might command the route through Salt Lake Valley and thereby obtain the right to construct a projected branch to Oregon. In these conditions it is not surprising to read that some portions of the work were done so roughly that they failed to pass the inspection of the Government surveyors, "little accustomed as those gentleman must be to the sight of creditable work." The Central Pacific Company, it seems, had the harder task. It had to cross the Sierra Nevada Mountains. The summit station was at a height of 7500ft. above the sea, and was approached by very abrupt gradients, as great as 1 in 20 in some cases. Wide ravines had to be crossed on timber trestling—the company was under obligation to the Government to replace its wooden structures by embankments or stone viaducts within a given period—and elaborate precautions had to be taken against snow drifts and avalanches. At the time of our writer's visit the company had carried its line over the Sierras to Wadsworth on the eastern side, and had a comparatively easy task before it of pushing on across the desert plains to the Rocky Mountains. The Union Pacific Company meanwhile had laid 900 miles of track from Omaha, and was within 240 miles of Salt Lake City. So far the prairie lands through which it had passed had presented no natural obstacles to the engineer, but before it was the difficult Rocky Mountain country. The magnitude of the task undertaken by the Union Pacific Company, rather than the technical difficulties involved in it, called forth our admiration. To drive a railway for eleven hundred miles through a wilderness, parts of which were infested by hostile Indians, where water was scarce and where nothing in the shape of materials or provision for the working parties could be obtained, was, we said, a task calling for the manifestation of all that dogged perseverance and aptitude for enduring hardship which was at the same time the virtue and the vice of the Western American character.

TRAILER WAGON TO CARRY 85-TON LOADS

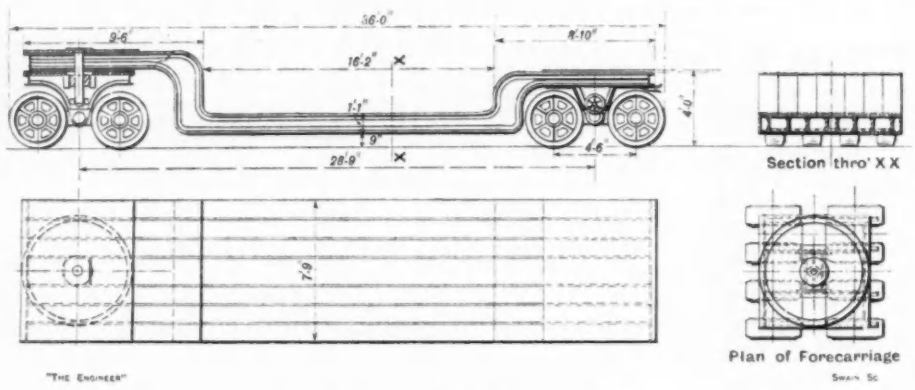
JOHN FOWLER AND CO. (LEEDS), LTD., ENGINEERS



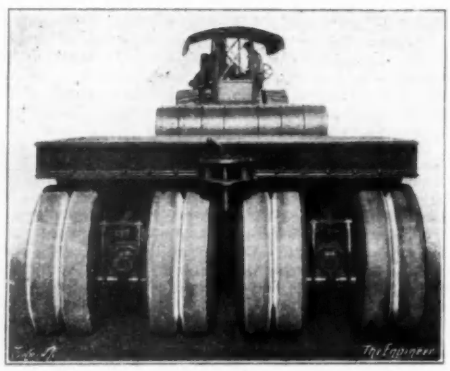
Trailer Wagon to Carry 85-Ton Loads.

In order to facilitate the road transportation of very large and heavy pieces of machinery which exceed the railway loading gauge and are too heavy for the railway rolling stock, John Fowler and Co. (Leeds), Ltd., have recently constructed to the order of a well-known firm of carriers a trailer wagon of unusual design and dimensions, which is capable of carrying loads up to 85 tons. In the case of objects which stand very high, one of the difficulties which are met with in road transport is that of clearing the bridges and other overhead structures, such, for instance, as tramway standards, and to get over this trouble the platform height had to be restricted to 2ft. from the ground level. That left a very small margin for clearance, and the girders which form the frame had to be closely restricted throughout.

As will be seen from the illustrations, the trailer has a flattened U-shaped body. It is 37ft. long and 7ft. 9in. wide, with a loading space of 16ft. 1in. in the "well," a platform height, unloaded, of 2ft., and ground clearance 11in. The girders are of built-up construction, the central webs being cut out of flat plates with the flange plates pressed and bedded on to them and fastened with angle irons. The girders are constructed with an initial camber of ¾in., and straighten out under load. Every rivet on the top of the platform is countersunk, as are also those underneath the "well" of the frame. This method of construction has been adopted in order to give the maximum clearance, both above and below the frame. The skill of the plater was tested to the uttermost in bedding the heavy plates evenly into the curvature of the frame, and the illustrations show how successfully this part of the work has been carried out. Altogether, upwards of 4000 rivets were used, and for most of them holes had to be drilled after the girders had been built up. It should be mentioned that all the girders have single webs, except the broad central girder, which has a double web with space between the plates wide enough to accommodate the king pin of the forecarriage.



ARRANGEMENT OF TRAILER WAGON



REAR VIEW OF WAGON

The arrangement of the sixteen road wheels is patented. The wheels are 3ft. 0½in. diameter overall, and are shod with heavy twin rubber tires. The wheels are arranged in sets of four, and each pair of wheels is free to swivel laterally. Between the two pairs in a set is a longitudinal axle, which can swivel in a fore-and-aft direction on the main axle of the bogie, an arrangement which gives an equal distribution of weight on uneven ground. The front bogie which is attached to the tractor is free to swivel on a king pin, as shown in the drawing, but the rear bogie is rigidly secured to the framework of the wagon.

Internally expanding brakes are fitted to each of the rear wheels, the operating gear being arranged so that each set of wheels can be braked by a single hand wheel on the side of the wagon.

The Choice of Propelling Machinery.*

By Professor PERCY A. HILLHOUSE, D.Sc.

THE shipowner who intends to increase his fleet is to-day faced by such a large variety of methods of propulsion that his superintending engineer must find it a matter of no small difficulty to advise him wisely as to the type of machinery which will, all things being considered, prove most satisfactory.

I am not an engineer, and am not competent to discuss from an engineer's standpoint the relative merits of different machinery installations as such. To do so would take more knowledge and more time than are at my disposal. I propose, therefore, to confine my attention to one particular case, and to consider the engineering alternatives from the naval architect's point of view; to investigate the influence which the choice of propelling machinery has upon the ship which is to carry it.

I propose to consider the particular case of a vessel which is desired to satisfy the following conditions :—

To carry 5000 tons of chilled beef at 115 cubic feet per ton on a mean draught of 24ft. 8in. in salt water, and to have an average service speed of 15 knots at sea, in moderate weather, on a homeward voyage of 6500 miles. At this draught she is to carry also sufficient fuel for the homeward trip and for port use plus two days' margin, together with the necessary weights of crew and effects, stores, and water.

This is a very specialised class of ship to which no general formula could well be applied. Meat space is specially valuable, and every effort is made to avoid encroachments upon it. Bulkhead stiffeners and brackets, deck beams and knees, tank tail brackets and similar structural members must be kept as small as possible. 'Tween deck heights and depths of holds must be arranged to suit the dimensions of the carcases without waste of space, the units being about 6ft. 8in. or 9ft. 8in. meat space clear of brine pipes and insulation. These sizes lead to 'tween deck heights of about 7ft. 10in. from beam to beam, and to 3ft. jumps in the depths of hold. The moulded depth cannot, therefore, be chosen at random, and can only be changed by jumps of 3ft. or of 7ft. 10in. The tank top generally follows the shear and round of beam, so that the clear depth of hold may be as uniform as possible. In this way, space that cannot be occupied by hanging carcases is made useful as part of the double bottom for the carriage of oil or water.

Twin-screw internal combustion engines were first considered, and it was estimated that a vessel 460ft. by 65ft. by 38ft. 3in. to the shelter deck would meet all the requirements. These are moulded dimensions, the depth being such as to give one 9ft. 8in. meat unit in the hold and three 6ft. 8in. 'tween deck meat units. A combined forecastle and long bridge, giving another 6ft. 8in. meat unit were required to obtain the necessary meat capacity. This increased the depth to 46ft. 1in. amidships, and brought the length-depth girder ratio just under 10. The addition of a cruiser stern brought the useful water-line length up to 480ft., and upon this length, with moulded breadth and draught, the speed-length ratio and block coefficient have been calculated.

The weight account is as follows :—

	Tons.	Per cent.
Hull	5,370	34·3
Refrigerating machinery and insulation	2,500	15·6
Propelling machinery	1,500	16·0
Oil fuel	950	
Meat	5,000	32·0
Crew, stores, and water	350	2·1
Load displacement	15,670	100·0

This give a block coefficient of 0·7175, and the speed-length ratio is $(15 \div \sqrt{480}) = 0·685$.

To obtain a service speed of 15 knots with this starting displacement, it is estimated, by comparison with the performances of previous vessels on the same service, that 7750 B.H.P. will be required, and the consequent fuel account is :—

	Tons.
Fuel for 6500 miles at 15 knots, at 0·505 lb. per B.H.P. per hour	760
Two days' margin	84
Port use	106
	950
For the outward voyage, vessel light and refrigerating machinery not in use	720
Total capacity required	1670

Space for this quantity of oil can easily be found in the double-bottom tanks, in addition to ample capacity for the necessary fresh water.

The gross tonnage would be about 10,250; net, about 6500.

As an alternative to the above, let consideration be given to propulsion by means of twin-screw single-reduction geared turbines, obtaining steam from coal-fired cylindrical boilers. It is at once evident that a larger vessel will be required, since space must be found for boilers and coal bunkers, and, after a process of trial and error, it will be found that a vessel having the following particulars satisfies all the given conditions :—

Moulded dimensions, 500ft. by 70ft. by 38ft. 5in., with a cruiser stern and an effective waterline length

* Institution of Engineers and Shipbuilders in Scotland. Abstract.

of 520ft. The extra depth is due to an increase of ½in. in the depth of the deck beams, due to their greater span.

A much greater proportion of the length is now occupied by the propelling machinery and fuel than is the case of the motor ship.

The weights are :—

	Tons.	Per cent.
Hull	6,400	34·7
Refrigerating machinery and insulation	2,500	13·5
Propelling machinery	1,450	22·2
Coal	2,650	
Meat	5,000	27·0
Crew, stores, and water	475	2·6
Local displacement	18,475	100·0

Block coefficient, 0·725; speed-length ratio, 0·658; 1·06 — 0·329 = 0·731; the vessel thus being slightly finer than need be.

For the service speed of 15 knots, about 8300 S.H.P. would be necessary, and the fuel requirements would be :—

	Tons.
Coal for 6500 miles at 15 knots, at 1·41 lb. per S.H.P. per hour	2,260
Two days' margin	250
Port use	140
	2,650
For the outward voyage	2,150
	4,800

Of this, the permanent bunkers, side and cross, would contain the 2650 tons, while the 2150 tons would either be stowed in No. 4 hold and 'tween decks, and trimmed into the permanent bunkers on the termination of the outward voyage or purchased in the Argentine. The gross tonnage would be about 12,000; net, about 7700.

From the naval architect's point of view, a comparison of the above particulars of two vessels to perform the same service is greatly in favour of the motor ship. The larger turbine vessel would have slightly better sea-going qualities; the stability effect of her greater breadth would be to some extent offset by the higher position of the fuel. It must be remembered, however, that this is a particular case, and that other conditions might alter the whole aspect of the problem. Considerations of delivery, initial and running costs, and other factors might sway the owners' preference towards the larger vessel. Orders have, in fact, recently been placed for chilled meat carriers with turbine propulsion and coal-fired boilers. The final decision does not lie with the designer but with the owner who has to handle the ship and obtain a profit from her activities.

EDUCATIONAL INTELLIGENCE.

FARADAY HOUSE: SCHOLARSHIP EXAMINATIONS.—The annual examinations for a Faraday Scholarship of fifty guineas per annum, tenable for two years in college and one year in manufacturing works, and for a Maxwell Scholarship of fifty guineas per annum, tenable for one year in college and one year in works, will be held at Faraday House on April 9th, 10th and 11th, 1929. Exhibitions may also be awarded to candidates who acquit themselves creditably in the above examinations, but who do not obtain the necessary number of marks to qualify for the Faraday or Maxwell Scholarship. Further particulars may be obtained from the Registrar, Faraday House Electrical Engineering College, 62–70, Southampton-row, London, W.C. 1.

UNIVERSITY OF LONDON.—A course of five lectures on "High-voltage Cables" will be given at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2, by Mr. L. Emanueli, of Milan, the chief electrical engineer of the Pirelli cable manufacturing organisation, at 5.30 p.m. on February 20th, 22nd, 26th, March 1st and 5th, 1929. Admission will be free, without ticket. The lectures, which will be illustrated by lantern slides and possibly by cinematograph films, are addressed to students of the University and to others interested in the subject. A detailed syllabus will be available at the lectures, or may be obtained on application to Mr. Edwin Deller, Academic Registrar, University of London, South Kensington, S.W.

CATALOGUES.

HANS RENOLD, Ltd., Didsbury, Manchester.—1929 edition of "Renold Stock Chain Drives."

O. N. BECK, 11, Queen Victoria-street, E.C. 4.—A leaflet describing the "Beck" safety belt mounter.

J. BLAKEBOROUGH AND SONS, Ltd., Brighouse, Yorks.—List 112 of "Blakeborough" revolving water screens.

PROGRESSIVE ENGINEERING COMPANY, Ltd., Aylesten Park, Leicester.—"Fans for all Industrial Purposes."

SIMMS MOTOR UNITS, Ltd., Percy Buildings, Gresse-street, W. 1.—Publication concerning the Simms-Jurid link coupling.

WORTHINGTON-SIMPSON, Ltd., Queen's House, Kingsway, W.C. 2.—A small bulletin on centrifugal pumps for condensing plants.

YARROW HOME AND HOSPITAL FOR CHILDREN.—In these days of high cost of living, people of limited means are sometimes placed in a difficulty when their children are ill or need operations and afterwards require a change of air and much careful attention during convalescence. We therefore think it cannot be too well known that the Yarrow Home and Hospital for Children, Broadstairs, Kent, was founded specially for the children of those who are not too well endowed with this world's goods. At this Home a child recovering from illness or an operation, or needing a long course of medical or surgical treatment, receives, amid the happiest possible surroundings and companionship, careful nursing and attention, such as could ordinarily only be obtained at expensive nursing homes. There are beds for fifty boys between the ages of four and twelve years, and for fifty girls between the ages of four and fourteen years. In special cases these age limits may be exceeded by two years. The fee is one guinea per week and travelling expenses. Applications for the entrance of patients are welcomed from professional people, such as members of the Institution of Civil Engineers, architects, artists, authors, clergymen, members of the medical, legal, and other professions, members of scientific societies, officers of the Navy, Army, and Royal Air Force, officers of the merchant navy, schoolmasters, university professors, &c. The London office is at 116, Victoria-street, Westminster, and the secretary will be pleased to send full particulars to anyone who is interested.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Staffordshire Iron and Steel Institute.

AT the sixty-second annual dinner of the Staffordshire Iron and Steel Institute, at Dudley, on Saturday last, reference was made by speakers to the causes of and remedies for the present depression in the iron and steel industries. Yet Sir Gilbert C. Vyle, President of the British Engineers Association, in proposing the toast of "The Iron, Steel and Coal Trades," called for modernisation of selling methods in order to secure 100 per cent. capacity output, which was one of the chief essentials to the future prosperity of the industry. He believed that far too much material which could be manufactured in this country was being imported. If the manufacture of the great quantity of stuff which was coming into this country from abroad were added to the present load of our factories and foundries, it would have a wonderful effect upon the country's prosperity and in reducing prime costs. Sir Gilbert submitted that there was a great future in England for steel, but contended that the home consumption should be greater. He pointed out that in the United States, with a population of 125,000,000 last year, 50,000,000 tons of steel were used for domestic and constructional purposes. On that basis England, with a population of 42,000,000, should be using about 17,000,000 tons a year. Last year, however, the total production of steel in this country was only about 8·8 million tons, although our total capacity for its manufacture was 15,000,000 tons. He regarded the future, however, with optimism. Responding, Mr. C. E. Lloyd, M.P. for Dudley, referred to the improvements effected in the iron and steel industry during the last seven years. He thought the proof that the manufacturers had "done their bit" in actual prices was disclosed by the Board of Trade returns, which showed that the iron and steel trade commodity figure was only 12 per cent. higher than in 1913. The corresponding figure for the other commodities as a whole was 38 per cent. It was a mistake to believe that they desired to reduce prices in order to reduce wages. The sole object of reducing prices was to get more work, and there was not an iron or steel manufacturer in the country who would not willingly increase prices at present if while doing so he could successfully face foreign competition. If the country would give them the chance of largely increasing their output they could look forward to a period of prosperity as the fruition of their efforts on behalf of the rebuilding of the industries.

The Future of Wrought Iron.

At the gathering referred to above Sir Gilbert C. Vyle expressed the opinion that there was a better time in store for the Staffordshire wrought iron industry. They had a lot to be proud of in Staffordshire, he said, because it was there they first made iron with coal instead of charcoal, and they also engaged in the newest puddling processes long before they were universally adopted. He found considerable comfort in thinking that bad as the times had recently been in Staffordshire, there was a little blue in the sky. People were beginning to realise that steel was steel, and that there was a limit to what steel could do, and that in certain directions yet to be explored there were new markets for British wrought iron to take the place of what he might call perishable steel. It was for those in that district to pursue the idea of trying to find new markets for the products for which they were famous. He ventured to think that with a little modernisation of their selling methods, the iron manufacturers ought to be able to fill the works almost up to their capacities.

Pig Iron.

The situation in the pig iron trade remains much as it was a week ago, neither buyers nor sellers being inclined to give way. Here and there it is reported the parties have met half-way, but no bulk of business has been transacted, the sales effected relating only to urgent current needs. The question is not whether the blast-furnacemen are unreasonable in asking that prices shall be paid which will give them a fair profit on their capital, but whether the industry is likely to be delivered from its troubles by such a move as has now been made by smelters. This is the first time that an attempt has been made to combine the pig iron producers from Yorkshire and Lancashire to Staffordshire and Northamptonshire in a common price policy, and their efforts can only meet with success so long as they present a solid front to buyers. Consumers of pig iron refrain from doing business on the new terms, and the fight appears to have developed into a siege. What the outcome will be it is practically impossible at the moment to determine. One thing seems fairly generally admitted; pig iron values are higher, though not to the extent of the half-a-crown advance demanded by the makers.

Steel.

Progress in the steel department continues, but at a slow pace. Constructional engineers are passing through a quiet period, and most of the work on the books is for comparatively light tonnages. Competition is keen even for the small schemes for which tenders are being invited. In the Midlands the tonnage of steel required for building purposes is small. A few inquiries are in the market, but they relate to no great bulk of material. There are evidences of augmented strength in the heavy structural steel branch, but they are less apparent here than in the North-East. Plate mills could do with considerably more business. Some of them are experiencing difficulty in keeping up the present rate of output without adding to stocks. Finished steel prices are unchanged. In the half-products department business is moderately good, but makers are not in the happy position of being able, as those in Middlesbrough and Sheffield have done, to advance prices. English billets sell in Birmingham at £6 5s., and sheet bars at about £6 2s. 6d. High carbon billets have become dearer. Continental material is "offered," but not "pushed," and the prices named are such as show little advantage to the purchaser over native prices when everything is taken into consideration. Foreign sheet bars and 2in. billets are quoted round £6, and joists £6 6s. to £6 7s.

Staffordshire Bar Iron.

Staffordshire makers of marked bar iron continue to consolidate their position, and the future is now more promising. Values are maintained at £12, at which figure they have stood for some considerable time. The market for Crown iron does not expand much, and local makers have great difficulty in securing any of the orders which come on to the market in face of the competition at much lower rates of other English makers. Prices have not varied from those prevailing a week ago. Nut and bolt and fencing iron is in better request, but the output from South Staffordshire mills is small. Belgian competition is less severe, but consumptive demand is not what it used to be, Darlaston nut and bolt works being only moderately employed. Staffordshire ironmasters continue to ask £8 10s. to £8 17s. 6d. for this material. Wrought iron tube strip is well called for and prices are unchanged at £10 12s. 6d.

Galvanised Sheets.

Galvanised sheet mills are well employed, and order books present a healthy appearance. Both the home and the export demands keep up, and makers of 24-gauge corrugated sheets experience no difficulty in getting between £13 12s. 6d. and £13 15s. per ton for their production.

Birmingham's Great Bridge Scheme.

For some time past the proposal to construct a viaduct across New-street Station, Birmingham, has been a matter of discussiom. An ultimate expenditure of £925,000 will be involved if the Birmingham City Council decides to proceed in due course with the great scheme. The proposal embraces the cutting through of that portion of the Queen's Hotel opposite the end of Stephenson-place, passing through the building under an archway, and constructing a steel truss bridge in two spans across the station, one span being of 192ft. and the other of 212ft. This week the City Council was invited to take the first steps for putting into operation the scheme, the Public Works and Town Planning Committee having reported that "while it may not be opportune to carry out the scheme immediately, the committee feels that the time has arrived when it becomes imperative for the City Council to express its views upon the advisability of providing for it in the future."

Cannock Chase Coal Trade.

In December the collieries in the Cannock Chase and Pelsall area made the best profit on their coal output that has been obtained for more than twelve months. The gain was 9·59d. on every ton of coal raised. This is, however, only the second profit recorded in any month for more than a year. Miners' wages during February in this area, based on the ascertainment for October, November and December, will remain at the minimum of 42 per cent. on basis rates, the owners' real ability to pay being 25·83 per cent., compared with 21·62 per cent. for January. The minimum wage of stallmen is 9s. 4d. per day. The owners' accumulated deficit now stands at £2,779,660.

Contracts Inspector.

Owing to the immensity of the work now being executed under the control of the Birmingham Public Works Committee, and to the difficulties confronting it in certain respects, it has been deemed advisable to appoint a chief inspector of all the building contracts, whose duty it will be to control the clerks of works on the respective contracts, and to obtain the complete performance of the contract entered into by the contractors with the Corporation. To this position Mr. A. E. Lee has been appointed.

Unemployment.

Unemployment in the Midlands shows another decrease, the current total being less by 7714 than the figure for the previous week. The total now stands at 186,315, to which Birmingham contributes 27,287

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

An Explosion and an Inquiry.

THE controversy following upon the accident at the Bradford-road gasworks of the Manchester Corporation in August, 1927, has gone a stage further by the publication of the outline of the report of the special committee of inquiry appointed on the recommendation of the Manchester City Council as a sequel to the rejection by the Council at the January meeting of the Gas Committee's report on the matter. Broadly, the committee of inquiry supports the conclusions and recommendations of the Home Office Inspector, for it expresses the opinion that the responsibility for working the gasholders concerned rests directly on the Gas Committee, that the inspection of the plant in recent years had been inadequate, and that by failing to appoint a chief engineer the Gas Committee incurred a very grave responsibility. The appointment of a chief engineer and the careful defining of the functions of the present general manager and the secretary are important recommendations of the committee of inquiry, which also states that it sees no reason why the conclusions of the Home Office Inspector should not be accepted as reasonable.

Sewage Disposal on German Lines.

As a result of a visit to Germany of members of the Rivers Committee of the Manchester Corporation, a recommendation has been made that a sub-committee should be appointed to consider the application of the German system of sewage disposal, involving the secondary digestion of the sludge, and the recovery and utilisation of the gaseous products, at the Davyhulme works, Manchester. A report prepared by the visitors draws attention to the fact that the process in question is becoming almost the invariable custom in Germany, and promises, where assisted by heat, a rapid and economic system of sewage disposal.

New Bridges ?

A suggested scheme for the construction of an additional bridge across the river Ribble, from a point near Longton on the south side to a point opposite Clifton village on the north side, has received the approval of the Fylde Regional Town-planning Advisory Committee, at a meeting at which representatives of the Lancashire County Council, the Corporations of Blackpool and Lytham St. Annes, and various Urban and Rural District Councils interested were present. Before, however, any concrete action can be taken, the scheme has to be submitted to a joint meeting of the Local Authorities, and also to the South-West Lancashire Regional Committee. Another bridge construction proposal is that of the Main Roads and Bridges Committee of the Lancashire County Council for a structure over the Rochdale Canal in Manchester-road, Droylsden, at a cost of £13,290, of which the Ministry of Transport is expected to furnish £6145.

A Cheshire Joint Electricity Board.

Differences which arose between the Alderley and Wilmslow (Cheshire) Electricity Board and the electricity supply company for the area have now been adjusted, and the Board has taken possession of the works, the purchase price being £113,000.

Big Order for Locomotives.

A useful addition to the order books of the Vulcan Foundry, Ltd., Newton-le-Willows, is an order placed by the Indian State Railways for sixty locomotive boilers.

Non-ferrous Metals.

After a series of declining markets, tin has made a pronounced recovery during the past week, and thereby has lived up to its reputation for providing the spectacular. Up to the end of last week, however, there had been little change in the situation, so far as prices were concerned, compared with that recorded in this column a week ago. The early sessions of the present week have witnessed a marked improvement in prices, which was due, apparently, primarily to the development of a more bullish statistical position, although a fair amount of buying interest has also been shown. The net result has been an advance in quotations in the neighbourhood of £8 a ton, compared with those quoted at last report, current values being the highest since the beginning of December, when the latest decline set in. The copper section of the non-ferrous metals market has not been lacking in interest, for here also a very substantial rise has occurred. Transactions in the metal have been on a good scale, and there have been further advances in both standard and refined. Renewed firmness has been displayed in the spelter section, due, in a measure, to the market belief that progress has been made in the output control scheme among continental makers. In the case of lead, there has been a fairly good movement, and prices of both English and foreign metal are appreciably dearer on the week.

Iron and Steel.

Lancashire foundry iron users, in spite of the diversity of prices which Midland makers of pig iron are still quoting, recognise that the lowest figure mentioned represents a decided advance on values current in the first half of last month. Many of them, moreover, are beginning to take the view that the recent era of very cheap iron has come to an end, and in some instances this has led to the placing of a number of contract orders locally for fair tonnages, both by users and merchants. Staffordshire and Derbyshire offers, for delivery in the Manchester district, vary from 69s. per ton to about 72s. 6d., with Middlesbrough at 79s., Scotch at 88s. to 90s., and hematite at 83s. to 83s. 6d. per ton. There is a moderate early rolling business being placed by constructional firms in the steel market, and although few new contracts have been received of late for general and boiler plates, fair deliveries of these have been made within the past few days against existing orders on the books. For small bars the demand is maintained at its recent improved level. Sections are very firm at £7 17s. 6d. per ton, as are also boiler plates at £9 15s. to £10, according to quality, small bars at £8 to £8 2s. 6d., large bars at £8 17s. 6d., and general plates at £8 12s. 6d. Continental semi-finished products have advanced a further shilling or two on the week, though in view of the fact that supplies of these are virtually unobtainable within a reasonable period they must be regarded as more or less nominal as far as this market is concerned. Foreign finished steel products also are very firm, but the demand is quiet generally.

BARROW-IN-FURNESS.

Hematite.

The hematite iron market continues to be brisk, and there is a fair amount of business being done in forward deliveries, which would seem to point to a continued demand. At some of the works, particularly in Cumberland, stocks are coming down, and at the present rate it will not be long before they are cleared. That will be a good thing for makers generally, for it is thought that the present desire to clear stocks is having the effect of keeping down the price of iron, which, instead of rising, is inclined to be easier. As soon as stocks are cleared and if the outlook for the trade is the same as obtains at present, then there will probably have to be an increase in output generally. The increase in the number of furnaces will, to a certain extent, depend upon the state of the steel trade, and the question as to whether the rail departments, which, when running, take a fair tonnage of iron, are requiring any or are stopped owing to lack of orders. Special qualities of iron are in fair demand, and the Continent continues to be a moderate customer. The iron ore trade remains about the same. The steel trade is not brisk, but orders held will keep the mills going for a period, though fresh orders are needed if the run is to extend for a substantial period.

Shipbuilding.

It is hoped that there will be further contracts forthcoming from the Admiralty for Vickers-Armstrongs works here, and it is rumoured that three submarines and a flotilla leader might be built at Barrow. The local naval construction works are busy on submarines at present, and, apart from orders held for the Admiralty, are concentrating on the Chilean orders.

SHEFFIELD.

(From our own Correspondent.)

The Heavy Steel Trade.

WITH regard to the heavy side of the local steel trade, one can do little more this week than repeat the story which has already been told several times recently, of considerable activity on the basic side and quietude on the acid. The furnaces making the former material continue to dispose of their output readily, and, in a good many cases, the high-carbon qualities are being used in place of acid steels. North Lincolnshire has benefited still more than Sheffield by the rise in the prices of continental basic steel. Busy conditions are the rule at all the works in that area, and capacity is being extended. As the works are of the most modern character, and have the advantage of being situated close to the ore supplies and within a short distance of coal and shipping, there is much justification for the claim that basic steel can be produced more economically there than in any other part of the world. There has been a considerable falling off in continental competition in Siemens steel, and the difference between home and foreign prices is narrowing so as to become almost negligible. Much work in the heavy manufacturing branches is having to be accepted at low prices. Places outside Sheffield, which have taken up certain heavy lines, have adopted a cutting policy which has deprived the city of some important contracts recently. The British railway companies have obtained lower prices than last year's in renewing their contracts for axles, tires, springs, and steel, and makers will get little or no profit on the work unless they can further reduce costs. A good sign of the benefit which may be expected to come to Sheffield from the improvement in shipbuilding is the fact that the heavy steel forge at John Brown and Co.'s is already fully employed on that class of work.

Special Branches and Tools.

Despite increasing competition from other centres there are still several special lines of steel manufacture which are almost confined to Sheffield. One of them is the provision of various types of fine steels for the motor industry. The demand is on a large scale, and keeps a number of firms busy. The call for stainless and non-corrodible steels continues to expand. A steady trade is being done in tool steels, but the year's bookings have not been up to anticipations. Patchiness is the rule in the tool trade, and bulk orders are difficult to obtain. The file and saw branches are quiet, and the garden tool season has had only a moderate start. A fairly good sale is reported for engineers' tools, but nearly all the firms producing these goods would welcome more work.

Forged Boiler Drums.

Sheffield has a special interest in the new series of express locomotives which are to be built by the London, Midland and Scottish Railway Company, as John Brown and Co. announce that they are constructing, at their Atlas Works, a number of special hollow forged boiler drums for these engines. This, it is stated, is an entirely new development which had its origin in Germany. These new boilers are designed on the Schmidt system, which has been modified to suit British conditions.

Other Railway Matters.

It is stated that over 100 locomotives are to be built at Derby this year, out of the 256 scheduled by the London, Midland and Scottish Company. Kitson and Co., Ltd., of the Airedale Foundry, Leeds, have secured a contract for the construction of fifteen locomotive boilers for the Indian State Railways. Messrs. Logan and Hemingway, of Doncaster, are the contractors for a large scheme of line widening for the London, Midland and Scottish Railway between Northfield and Barnt Green Stations, near Birmingham, in connection with which the important task of blowing up the Cofton Tunnel was carried out a fortnight ago. Thos. W. Ward, Ltd., of Sheffield, who have made many purchases of works and plant in Great Britain and abroad since the war, has now extended its operations to India, where it has just bought sixteen British-made modern locomotives from the Bombay Improvement Trust. The engines are of standard gauge, of the four-wheel coupled saddle tank type.

A Safeguarding Majority.

The Sheffield Chamber of Commerce has just taken an interesting ballot of its members on the important matter of safeguarding. The question was "Are you in favour of the principle of the extension of safeguarding to the iron and steel industry ?" There were 515 replies in the affirmative and only 46 in the negative. From the iron and steel trade itself, "Yes" was returned in 208 cases, and "No" in 15. In the cutlery, tools, silver and allied trades, the figures were respectively 115 and 10; in engineering, 22 and 1; other trades, 100 and 9; professional, 70 and 11. The percentage of voting papers returned to the number sent out was 62, and the percentage of voting papers returned in favour was 92.

Cutlery and Plate.

The cutlery and plate trades are slow in getting into their stride for the new year. Several large contracts have been booked, but in the majority of cases firms report that conditions are quiet. In connection with the new grinding regulations, progress is being made in adapting shops where sandstones are used, and in other cases a considerable number of abrasive wheels are being installed.

Hull Crossings Abolition.

Not much has been heard about this important matter for two or three weeks, but negotiations have been in progress, as a result of which the prospects of starting the work have improved. The estimated cost of the scheme is £1,217,000. The position has been that the London and North-Eastern Railway Company declined to take steps to place a Bill before Parliament until it received an assurance that the offer of the Unemployed Grants Committee, of which Lord St. Davids is chairman, to contribute £560,000, was guaranteed, irrespective of political changes. Last week Commander Kenworthy saw representatives of the Committee and on returning to Hull he stated that the Treasury would place no obstacles in the way, and that the Unemployment Grants Committee was prepared to guarantee its grant, providing the work was started within twelve months.

Municipal Matters.

The Tramways Committee of Sheffield City Council recommends acceptance of the tender of Steel, Peech and Tozer, Ltd., Sheffield, for the supply of 1000 tons of tramrails at £10 2s. 6d. per ton. In order to provide for the anticipated increased load next winter, the electricity engineer of York recommends the carrying out of extensions of the undertaking which will cost £27,770. Derbyshire County Council has had before it a scheme, prepared by the county surveyor, for the construction of a by-pass road continuing the main road from Little Eaton on the east side of the railway and rejoining the present main road north of the Holbrook level crossing. The length of the proposed road is 2700 yards, and the estimated cost £55,500. The Bridges and Highways Committee has adjourned consideration of the scheme, owing to the fact that the Ministry of Transport would not give an undertaking to contribute to the cost.

NORTH OF ENGLAND.

(From our own Correspondent.)

Coal Trade Activity.

PERHAPS the most encouraging feature of the industrial position in the North of England this week is the marked activity in the coal trade. The position has steadily improved week by week since the beginning of the year, and there is every indication that it will continue to gather strength for some weeks to come. New business for all descriptions of coals is freely indicated and inquiries come from all continental centres. Scandinavian demands are much more pressing than for a considerable time past, and merchants are beginning to feel that they are really on the eve of a steady trade, and the prospects for over the summer are encouraging. Under the present scale of operations at the pits, the output is not sufficient to meet the actual demands of this and next month, and fitters are going into the question of increased workings, and it only wants a little more confidence to encourage several owners to restart some of their pits. The wages position in Durham and Northumberland is also better. The accountancy ascertainments of proceeds and costs for both counties, which would determine wages in the present month if there were no minimum percentages on basis rates, show a small but almost identical improvement. In Durham the economic increase is 3·55 per cent., and in Northumberland 3·65 per cent. In the formula of the county agreements, the deficiencies are still high, being 36·80 per cent. in Durham and 28·68 per cent. in Northumberland. It is gratifying, however, to find that trade in both counties is moving in the right direction.

Cleveland Iron Trade.

The improvement in the Cleveland pig iron trade is well maintained, and business continues to come forward in increasing volume. The heavier requirements of the steel works have, in fact, created rather a scarcity in pig iron supplies. Thus the ironmasters are in a strong position, and whilst it is recognised that it would be dangerous to force up prices there is no difficulty in disposing of the current output at the prices which have ruled for nearly twelve months past. The export inquiry is slightly better, but it is chiefly home needs which have created the more favourable situation. The increased demand has resulted in more active conditions at the Cleveland ironstone mines, and two, which have been working from three to five days a week, have now been put on full time. No. 1 Cleveland foundry iron is 68s. 6d.; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge, 64s. 6d.

Hematite Pig Iron.

Conditions in the East Coast hematite pig iron trade show a slight further improvement. Home and export business is expanding, and the limited production is promptly taken up as it comes on to the market. Nearly all present transactions are in parcels manufactured to stipulated analysis, but values are based on the quotation for ordinary qualities, which may be given as 71s. 6d.

Ironmaking Materials.

Transactions in foreign ore are still few and small, but merchants adhere firmly to the equivalent of best

Rubio at 22s. 6d. c.i.f. Tees. Business in blast-furnace coke is improving, and prices are inclined to advance. Good medium kinds are 17s. 9d. delivered at the works on the North-East Coast.

Manufactured Iron and Steel.

In the manufactured iron and steel trade there are no quotable changes to record, but values of some commodities show a rather marked upward tendency. Continued enlargement of home, continental and Far Eastern demand seems assured. Makers of shipbuilding material are busy, and are likely to be busier. Producers of railway material confidently look for further substantial buying, while sheet manufacturers are not only well sold, but are now looking forward to spring buying.

Exports and Imports of Iron and Steel.

Although makers of Cleveland pig iron have only a small surplus after meeting the needs of their own steel works, it is gratifying to record an increase in the shipments of pig iron from the district during January, the total tonnage for the month being 18,851 tons, as compared with 15,812 tons in December. Largely owing to heavier shipments to Italy and Denmark, the foreign exports advanced from 9333 tons to 10,613 tons. For four months there has been very little variation in the total tonnage of the manufactured iron and steel shipments. Last month the figure was 62,319 tons, compared with 65,974 tons in December. South Africa was again the biggest customer, 15,150 tons being shipped to the Cape alone, whilst 14,588 tons went to India and Ceylon. Australia took 4190 tons, Argentine 3409 tons, and Netherlands, 2917 tons. In January the imports of pig iron into the river Tees totalled 5638 tons, an increase of 1500 tons compared with December. On the other hand, the imports of manufactured and semi-manufactured materials, totalling 9315 tons, were down by 5194 tons as compared with December. From November to January the iron and steel imports from foreign countries show a drop of nearly 10,000 tons, compared with the corresponding period of 1927–28. During the past three months the imports of various classes of material totalled 47,074 tons, compared with 57,270 tons for 1927–28, and 17,119 tons in 1913–14.

The Coal Market.

The Northern coal market presents a very strong tone, and in every section there is a particularly favourable tendency, which is encouraging the owners to take steps further to increase the output. At some pits double-shift working is again in force. Collieries and merchants are inundated with fuel inquiries, large steams being the most active feature. Prompt offers for supplies are keenly sought from day to day, but the chances of early delivery are not favourable, as output in Northumberland is booked for a few weeks ahead, and the stem sheets are very full. All the pits that are working can find an outlet for every ton of coal at firm late prices. Consumers are eager to cover their requirements for March, and have sufficient confidence in the stability of trade to desire to purchase over the rest of the year at just a shade less than current quotations. Steam coals have not been in a better position for a long while, and several idle pits are likely to open again if the present demand be maintained. Where a loading turn can be obtained, something more than even the current figures can be obtained for most classes of coal, and the persistence of the demand from many quarters is regarded as solid proof that the industrial situation in its broadest sense is showing genuine improvement. Best Northumberland steams are 14s. 6d. to 15s.; second steams, 14s.; unscreened steams, 12s. 6d. to 12s. 9d.; best Durham gas coal, 14s. 9d. to 15s.; second gas, 13s. 9d. to 14s. 3d.; and coking unscreened, 14s. to 14s. 6d. The coke section tends to more strength, as there is a good inquiry, and some important business is pending. Ordinary patent foundry coke is unchanged at 18s. to 18s. 6d., and gas descriptions are firmer at 18s. 6d.

River Tees Developments.

Plans for further developments on the north bank of the river Tees by Synthetic Ammonia Nitrates, Ltd., on reclaimed land have been presented to the Tees Conservancy Commissioners for their consideration and approval. These include new works and a wet dock to meet the company's increasing export trade.

Another Shipbuilding Order.

Smith's Dock Company, of Middlesbrough, has received another substantial order. The vessel commissioned is a self-trimming collier of 4500 tons deadweight, for North-East Coast owners. This makes thirty ships, large and small, ordered or being built at the Tees yard of the firm.

Ironworkers' Wages Advanced.

Under the latest ascertainment of the North of England Manufactured Iron Trade there will be an advance in the wages of puddlers and other forge and mill workers of 2½ per cent., which will bring the percentage above the base rate to 20.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE output from Clyde yards during the month of January was well up to the average, and amounted to six vessels of 37,611 tons aggregate. Included in the list of vessels launched were the following:—"Highland Hope," twin-screw motor ship, 14,137 tons, built for H. and W. Nelson, Ltd., London; "Eastern Prince," twin-screw motor ship, 11,000 tons, for the Prince Line, Ltd., London; "Jumna," cargo steamer, 6300 tons, for James Nourse, Ltd., London; and the "Korano," cargo steamer, 5000 tons, for Jugo-Slavian owners. The amount of new tonnage reported during the month of January is encouraging. While there has not been any specially large vessel ordered, quite a number of the orders placed indicate good-sized general cargo-carrying types. Compared with the beginning of the year 1928, the outlook for 1929 is distinctly brighter. Then the output exceeded the quantity of new business, while the position to-day is reversed.

Steel.

The improvement in the shipbuilding industry is reflected in the steel industry. Specifications are being received at a fairly steady rate, and it is confidently expected that this state of affairs will continue for some time. Light steel sheets are moderately busy, but heavy gauges are quiet apart from the influence of the shipbuilding industry. The continued firmness of continental prices and the benefits anticipated under the de-rating scheme have helped to produce a greater feeling of confidence in the immediate future of the trade.

Iron.

The demand for bar iron continues on restricted lines; but in any case business is more or less at a standstill, as most of the works are idle, meantime, as a result of the present deadlock between employers and employees on the question of hours. In pre-war days bar iron sold at almost equal prices to those prevailing for steel bars, but since the introduction of the eight hours' day, the increased costs of production of iron has been out of all proportion compared with steel, and the introduction of the three-shift system in 1919 caused the stabilisation of iron prices on a level at least £2 per ton higher than steel. In pre-war days the annual output of wrought iron was 250,000 tons, while the total production during the year 1928 only amounted to 47,000 tons. The re-rolled steel departments must also be affected by the deadlock, as most of the re-rolling of steel bars was carried on by firms who are also engaged in the production of bar iron and strips.

Tubes.

Producers of steel tubes are busy, especially in the hot-rolled department.

Pig Iron Prices Fixed.

Pig iron makers in Scotland have agreed not to sell foundry and forge qualities under the following quotations:—Foundry No. 1, 73s. 6d.; No. 3, 71s.; forge iron, 70s.; all per ton f.o.t. maker's works. A minimum price of 25s. per ton was fixed for hematite some time ago. The pig iron trade has been depressed for a considerable period, and at present the number of furnaces in blast is only twenty-one, compared with eighty in pre-war times.

Coal.

Owing to restricted outputs and the increased demands on home account, fuels for shipment have become very scarce and firm in price. Practically all qualities and descriptions of round coals have appreciated in price, and washed materials are comparatively firm. Lanarkshire splints are especially scarce. Aggregate shipments amounted to 220,912 tons, against 239,164 tons in the preceding week, and 188,364 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

THE position in the steam coal trade at the present time is that by far the bulk of the collieries are working with regularity. There is every prospect of this state continuing throughout this month, though the loading pressure may not be quite as heavy as was experienced lately, for the reason that the tonnage factor is slightly uncertain. Expectations that shipments last week would be good materialised, as the total is reported to have been just over 515,000 tons, which is well above the average. In fact, throughout the whole of last year the half-million mark was only exceeded four times, so that there is evidence in this fact alone that the conditions in the coal trade are now better. Whether the improvement has the elements of permanency is quite another matter. It is rather to be feared that there will be some tapering off in the activity prevailing, as apart from the question of tonnage supplies, foreign buyers may hold their hands, especially as with an advance in outward rates of freight, this means a higher c.i.f. price to be paid. At the moment there is no doubt that exporters have a fairly substantial number of orders to execute during the next few weeks, but large-sized tonnage is not showing up at all freely, and it may be that although collieries have very full order books they may not have tonnage put at their disposal just when they want it. The foreign inquiry has slackened off to some extent, and cannot be described as brisk, but most collieries are so well placed for this month, and in some cases for the early part of next, that they are not perturbed for the time being. It is now understood that the two firms which submitted the lowest tenders for the requirements of the Egyptian State Railways have received intimation of the acceptance of their offers. So far there is no news of the French Marine Authorities having bought, but information is expected shortly.

January Chartering Operations.

It is interesting to note that the chartering of tonnage during January reached a level in excess of the average for the past seven years, so that it is no wonder that the coal trade conditions in this country display a marked improvement. The total tonnage taken up, according to records, was 2,445,990 tons last month, which was the highest aggregate since March, 1927, when 2,591,230 tons were fixed. The fixings for Cardiff came to 1,324,030 tons, which was the best monthly aggregate for two years, while at Swansea the total of 247,680 tons was the highest since April, 1927. In the case of the Tyne the total of 874,280 tons chartered for January had not been exceeded since July, 1922.

Docks Overtime Work.

Reference was made last week to the fact that the coal trimmers and tippers in this district had decided upon the rejection of the proposals of the employers for working overtime at the docks. The proposals of the employers were framed for the purpose of improving the despatch of steamers trading to this district, and to enable the trade to compete with other exporting centres. The whole question came up again for discussion on Monday when the joint conference of employers and workmen's representatives was resumed. The proceedings were, however, again adjourned until the 19th inst., so that the men's leaders could have an opportunity of again consulting their executives and the men concerned at the various ports. Hopes of some amicable arrangement being ultimately come to are entertained.

Tin-plates by Road.

In connection with the development of road transport, it is interesting to note that one of the largest tin-plate undertakings in this country, viz., Richard Thomas and Co., has been sending supplies from its Cwmfelin works as far afield as London and Liverpool in large eight-wheeled motor lorries of the trailer type. These vehicles convey 10 tons of boxes of tin-plates, and it is claimed that not only is time saved, but the cost is lower than by rail or sea. It is also stated that a Liverpool firm has contracted to carry some 300 tons of plates to London and return with a similar quantity of sugar and like products.

Current Business.

The tone of the coal market continues to be very steady, but new business is not quite so voluminous. Colliery salesmen are still adhering to their prices, which, in the case of best Admiralty large coals, are 3d. above the minimum, and for leading Monmouthshire large 6d. to 9d. above the minimum. These figures are maintained for prompt supplies, but there is no doubt that salesmen would modify them for business for delivery ahead. Apart from the fact that tonnage is not now so plentiful as was the case recently, there is the prospect of production expanding. Work has been resumed at several pits, though at Nine Mile Point Colliery, where it was thought at one time that there would be a big return of men to work, progress in this respect has been disappointing. A section of the coal market which is particularly well maintained is that for smalls and sized descriptions. Patent fuel and coke are steady, but pitwood continues to be rather quiet, and ranges from 25s. to 26s.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. F. W. MORGAN and L. J. Wolf ask us to announce that, having acquired all the shares and other interests in the business of Wagner Electric Supplies, Ltd., of 66, Victoria-street, London, S.W. 1, they have decided to change the name of the company to Wolf and Morgan, Ltd.

ANGLO-HOLLANDIA MACHINERIES, Ltd., asks us to announce that the address of its London office has been changed from Faxfield House, 28, Watling-street, E.C. 4, to Mitre Chambers, 1, Mitre-street, Leadenhall-street, E.C. 3. Telephone, Avenue 8750; telegrams, Friedhoff, Ald, London.

ROLLS-ROYCE, Ltd., ask us to announce that, owing to ill-health, Mr. Basil Johnson has resigned his position as Managing Director of the Company as from January 31st. The Board has made the following appointments as from February 1st:—Mr. A. F. Sidgreaves, who was General Manager, has been elected a Director, and will become Managing Director; Mr. A. Wormald, General Works Manager, has been elected a Director; Mr. W. M. Cowen, who was London General Manager, becomes General Manager of the Company; and Major Cox has been appointed Sales Manager.

CONTRACTS.

THOMAS SMITH AND SONS (RODLEY), Ltd., of Rodley, Leeds, have received from the Stancliffe Estates, Ltd., of Matlock, an order to construct two large derrick cranes, each capable of lifting their full load of 25 tons at a radius of 65ft., and of working from the top of a quarry 150ft. deep.

MARRYAT AND SCOTT, Ltd., of 57, Hatton-garden, London, E.C. 1, have received from the Westminster Cathedral authorities an order for a lift to convey sightseers from the ground floor to the upper platform of the tower, a distance of 185ft. This is said to be the longest lift in London.

THE STREAM-LINE FILTER COMPANY, Ltd., 45, Horseferry-road, Westminster, S.W. 1, has received from the Central Electricity Board an order for filter plant to deal with the transformer and switch oils at each of the thirteen Stations included in the Central Scottish Grid Scheme. The value of the order is understood to be approaching £20,000, and is believed to be the largest single order for oil-filtering equipment ever placed.

LAUNCHES AND TRIAL TRIPS.

STEAMSHIP; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Mr. J. J. Boland, jun., and Captain Scott Misener, of Canada; dimensions 253ft. long; launch, January 25th.

HIGHLAND CHIEFTAIN, twin-screw motor vessel; built by Harland and Wolff, Ltd., to the order of H. and W. Nelson, Ltd.; dimensions, 520ft. by 69ft. by 35ft. 9in.; to carry passengers and cargo. Engines, two eight-cylinder double-acting four-cycle motor engines of the Harland-B. and W. type; constructed by the builders; trial trip, January 26th.

EX-B.W. ASSOCIATION ANNUAL REUNION.—The next dinner and reunion of Ex-British Westinghouse men will be held at the Hotel Cecil, London, on Friday, March 8th. Particulars and tickets may be obtained from the Hon. Treasurer, Mr. W. F. Warrilow, 40, Mildred-avenue, Watford, Herts.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	17/6 to 19/-
(1) Spanish	21/-
(1) N. African	21/-
N.E. Coast—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 15 0	—
No. 1 Foundry	3 13 6	—
No. 3 Foundry	3 11 0	—
N.E. Coast—		
Hematite Mixed Nos.	3 11 6	3 11 6
No. 1	3 12 0	3 12 0
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	3 4 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
,, ,, Foundry	3 2 6 to 3 5 0	—
(3) Northampton—		
Foundry No. 3	2 16 6 to 2 17 6	—
Forge	2 12 6 to 2 14 0	—
(3) Derbyshire—		
No. 3 Foundry	3 1 0 to 3 2 6	—
Forge	2 17 0 to 2 18 6	—
(3) Lincolnshire—		
No. 3 Foundry	3 1 0	—
No. 4 Forge	2 17 6	—
Basic	3 0 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 0 0 (a) / 4 3 6 (b) / 4 6 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
Double Best Bars	11 5 0	—
Treble Best Bars	11 15 0	—
Lancs.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	12 10 0	—
Midlands—		
Crown Bars	9 2 6 to 10 0 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 10 0 to 8 17 6	—
Gas Tube Strip	10 12 6	—

STEEL. (d)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ½in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 15 0	8 12 6
Sheets (Gal. Cor. 24 B.G.)	13 10 0	13 12 6 to 13 15 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 15 0	—
Soft Billets	6 15 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 0 0	—
Light Rails	8 5 0 to 8 10 0	—
Billets	6 15 0 to 9 10 0	—
Manchester—		
Bars (Round)	8 17 6	—
,, (Small Round)	8 0 0 to 8 2 6	—
Hoops (Baling)	10 0 0	9 15 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 12 6 to 8 17 6	—
,, (Lancs. Boiler)	9 12 6 to 9 17 6	—
Sheffield—		
Siemens Acid Billets	8 15 0 to 9 0 0	—
Hard Basic	8 15 0	—
Intermediate Basic	7 5 0 to 7 15 0	—
Soft Basic	6 12 6 to 6 15 0	—
Hoops	9 5 0 to 9 10 0	—
Soft Wire Rods	7 15 0	—
Midlands—		
Small Rolled Bars	7 15 0 to 8 0 0	—
Billets and Sheet Bars	6 2 6 to 6 5 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 12 6 to 13 15 0	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	9 15 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	228 0 0
,, ,, (three months)	228 5 0
Copper (cash)	80 10 0
,, (three months)	78 7 6
Spanish Lead (cash)	22 8 9
,, ,, (three months)	22 12 6
Spelter (cash)	26 7 6
,, (three months)	26 11 3
Manchester—	
Copper, Best Selected Ingots	82 0 0
,, Electrolytic	82 10 0
,, Strong Sheets	106 0 0
,, Tubes (Basis Price), lb.	0 1 2½
Brass Tubes (Basis Price), lb.	0 1 0¾
,, Condenser, lb.	0 1 2¾
Lead, English	24 5 0
,, Foreign	23 0 0
Spelter	26 12 6
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/10 per lb.	
Ferro Tungsten	1/6¼ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/6
,, ,, 6 p.c. to 8 p.c.	£20 12 6	7/-
,, ,, 8 p.c. to 10 p.c.	£20 10 0	6/-
,, ,, Specially refined		
,, ,, Max. 2 p.c. carbon	£33 0 0	12/-
,, ,, ,, 1 p.c. carbon	£37 0 0	15/-
,, ,, ,, 0·70 p.c. carbon	£44 0 0	17/-
,, ,, ,, carbon free	1/- per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£13 15 0 for home; £13 10 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£19 0 0 scale 6/- per unit	
,, Vanadium	14/- per lb.	
,, Molybdenum	4/2 per lb.	
,, Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/3 per lb.	

FUELS.

SCOTLAND.

(Prices not stable.)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	14/6
,, ,, Ell	18/-
,, ,, Splint	17/- to 18/6
,, ,, Trebles	15/6
,, ,, Doubles	14/-
,, ,, Singles	13/-
Ayrshire—	
(f.o.b. Ports)—Steam	14/6
,, ,, Jewel	17/6
,, ,, Trebles	16/-
Fifeshire—	
f.o.b. Methil or Burntisland—Steam	14/6 to 16/-
Screened Navigation	18/-
Trebles	16/6
Doubles	14/6 to 15/-
Singles	13/9
Lothians—	
(f.o.b. Leith)—Best Steam	15/-
Secondary Steam	14/6
Trebles	16/- to 16/3
Doubles	15/-
Singles	13/9 to 14/-

ENGLAND.

(8) N.W. Coast—	
Steams	23/-
Household	38/6 to 51/-
Coke	22/-
Northumberland—	
Best Steams	14/6 to 15/-
Second Steams	14/-
Steam Smalls	9/3 to 9/6
Unscreened	12/6 to 12/9
Household	21/- to 27/-
Durham—	
Best Gas	14/9 to 15/-
Second	13/9 to 14/3
Household	21/- to 27/-
Foundry Coke	18/- to 19/-

Sheffield—	Inland.	Export.
Best Hand-picked Branch	26/- to 27/6	—
Derbyshire Best Bright House	22/6 to 24/-	—
Best House Coal	20/6 to 21/6	—
Screened House Coal	17/- to 18/-	—
,, ,, Nuts	16/- to 18/-	—
Yorkshire Hards	15/- to 16/-	—
Derbyshire Hards	15/- to 16/-	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	4/6 to 6/-	—
Smalls	3/6 to 4/-	—
Blast-furnace Coke (Inland)	14/6 at ovens	—
Furnace and Foundry Coke (Export), f.o.b.		19/- to 19/6

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	19/3 to 19/6
Second Smokeless Large	19/- to 19/3
Best Dry Large	18/6 to 19/-
Ordinary Dry Large	18/- to 18/6
Best Black Vein Large	18/9 to 19/3
Western Valley Large	18/6 to 19/-
Best Eastern Valley Large	17/6 to 18/3
Ordinary Eastern Valley Large	17/- to 17/6
Best Steam Smalls	13/6 to 14/-
Ordinary Smalls	12/- to 13/-
Washed Nuts	18/- to 24/-
No. 3 Rhondda Large	20/6 to 21/6
,, ,, Smalls	14/6 to 15/-
No. 2 ,, Large	17/6 to 18/-
,, ,, Through	16/- to 17/-
,, ,, Smalls	12/6 to 13/6
Foundry Coke (export)	27/- to 37/-
Furnace Coke (export)	19/- to 21/-
Patent Fuel	20/- to 21/6
Pitwood (ex ship)	25/9 to 26/3
Swansea—	
Anthracite Coals:	
Best Big Vein Large	33/- to 35/-
Seconds	25/- to 29/-
Red Vein	22/- to 27/-
Machine-made Cobbles	40/- to 43/6
Nuts	36/- to 43/6
Beans	23/6 to 25/-
Peas	16/6 to 17/6
Breaker Duff	9/- to 9/3
Rubbly Culm	9/- to 9/6
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	9/6 to 12/-
Cargo Through	15/6 to 16/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.t. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our own Correspondent in Paris.)

Paris Water Supply.

THE official inquiry which is being held in the departments affected by the proposal to supply Paris with water from the Vals de Loire reveals that there is no slackening of local opposition to the scheme, the belief being that the sending of a million cubic metres of water to Paris daily will exhaust the subterranean supplies, would lower the level of the river Loire, and might dry up the wells upon which a large section of the population depends. In view of this local opposition the Paris Municipality is sending a commission of technical experts to the district to investigate the objections raised and to see if there is really the slightest danger of the proposed works affecting the prosperity of a rich agricultural region. If the commission's report should show that there is such a risk, the scheme would be modified, for only when the Paris Municipality is assured that the local populations will not suffer from any exhaustion of the underground supplies, will it ask Parliament to declare that the Vals de Loire scheme is "a work of public utility," which means that the local objections would be over-ruled. In the past, so much money has been spent upon the carrying out of partial schemes, which have given only inadequate results, that it has been decided to do something which will settle once and for all the problem of supplying water to Paris and the Department of the Seine.

Continuous Brakes.

The Government of the Saar is stated to be applying to the League of Nations for assistance to raise a loan of 60 million francs for the equipment of goods trains with continuous brakes. This work must obviously be done without undue delay, because all the trucks in Germany have long been equipped with Kunze-Knorr brakes, and in the course of a few years the whole of the goods trains in France will have Westinghouse brakes, so that the Saar railways must decide at once upon its preference for one or the other system. Judging from the way in which it is proposed to launch the loan, it would appear that the Saar railways have selected the Kunze-Knorr brake, since there is a suggestion that the loan will be guaranteed in Germany, which naturally does not meet with approval in France, where it is affirmed that the French Government would willingly offer the same guarantee on condition that the Westinghouse brake is chosen. Moreover, it is regarded as somewhat unfair that the German brake should be adopted in view of the fact that, as the Saar is within the French Customs area, and is separated from Germany by a high wall of tariffs, the great bulk of the traffic in the Saar is carried on with France, a state of things which will continue for another six years, when the Saar will have to vote upon its future status.

Coal.

The returns of coal output at the French collieries in 1928 give a total of 52,429,468 tons, or 417,230 tons less than in the previous year. In 1913 the output was 40,844,218 tons. The number of hands increased from about 200,000 in 1913 to 300,000 after the reconstruction of the collieries, and this gives a fair idea of the development of the colliery industry as the result of the modern equipment of the mines and the better organisation of the industry. At the same time, the coke production increased from 2,940,194 tons in 1913 to 4,399,932 tons in 1928, the latter total being 331,724 tons more than in the previous year. The coal output has not only reached its maximum, but has shown signs of retrograding for some time past, and it has been found difficult to avoid an excessive accumulation of stocks. One cause of this is the geographical situation of the collieries which brings them into direct competition with the Belgian and Saar producers, and they are unable to compete with British coal in the south-western parts of France, particularly at the ports, where preference is shown for British steam coals.

Labour.

The industrial future will obviously be affected to a more or less extent by the labour problem, which is at the moment occupying a good deal of attention, because it is difficult to see how the present rate of development can continue unless there is a proportionate increase in the labour supply. The main object of organising a system of immigration was to provide labour for the mining and agricultural industries, which the French themselves abandoned for more lucrative and easier employment in the mechanical and other industries. The foreign labour is therefore essentially unskilled, but, notwithstanding the efforts to keep foreigners to the industries for which they were brought into the country, they have drifted largely into the mechanical industries where they often make good money as "specialised labourers." This invasion has raised a serious problem quite independent of industrial considerations, and the question is asked how far it will be safe to encourage such immigration, since it introduces elements of trouble that must be guarded against? Either more labour must come into the country, or means must be found of dispensing with it as much as possible by the introduction of more machinery and new processes. That is being done, and will continue to be done until it becomes possible to carry out mechanical operations of all kinds with a minimum of labour. It is by no means certain that this move will be entirely successful, for where work is of an essentially variable character it is often convenient and cheaper to employ more labour than machinery, which may remain idle for considerable periods. In any case, the manufacturing industries are undergoing a process of organisation in the way of making up for the labour deficiency by a better application of mechanical methods, but it is difficult to see how far this can be done in view of the growing scarcity of skilled labour.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

SWITCHGEAR.

302,973. September 23rd, 1927.—IMPROVEMENTS RELATING TO THE PROTECTION OF DYNAMO-ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2; Percy Hugo Harding, of 23, Beaufort-gardens, Hendon Central, London, N.W. 4, and John Melville Goodall, of 25, Park-road, High Barnet, Hertford.

The protective device described in this specification is specially applicable to the protection of a high-voltage machine such as a 10-kV, direct-current generator. The electro-magnetic device A controlling the field suppression switch B comprises a core provided with two windings, one C arranged to be connected to a steady source of current, and the other D to the machine E to be protected. In the example shown, the winding D is connected in series between the machine E and the high-potential bus-bar or feeder F. Alternatively, it may be connected in series between the machine E and earth or neutral bus. These two windings C and D are arranged so as to oppose one another, and, under normal

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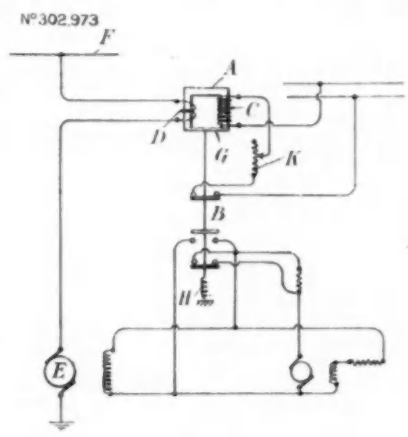

conditions, the magnetic force due to winding C, which is the holding winding, predominates over that due to the winding D—the bucking winding—sufficiently to maintain the armature G, which forms part of switch, in an attracted position against a bias applied by means of a spring H. At a pre-determined value of overload, however, the resultant of the magnetic forces no longer exceeds the biassing force, and the armature starts to move to the unattracted position. As soon as it leaves the pole pieces, the effect of the resultant magnetic force is very much reduced because of the air gap introduced into the magnetic circuit through the armature, with the result that the armature is then very quickly operated to its reset position by the biassing spring. The bucking winding D may be a single turn or bar. For varying the value of the overload at which the field suppression switch is to be operated, an adjustable resistance K may conveniently be included in circuit with the holding winding, or a variable magnetic shunt may be associated with the magnetic core.—*December 24th*, 1928.

303,259. December 2nd, 1927.—METHODS OF STARTING SQUIRREL-CAGE MOTORS, Frank Smith, of 46, Lauhton-road, Worsley, near Manchester.

The stator windings indicated at A, B and C may be electrically connected on the machine, with the exception of a connection between two of the phase windings A and C being omitted. The terminals of the windings including the free ends of the windings A and C, are connected by four conductors to switch contacts D and E in the starting apparatus. Associated with

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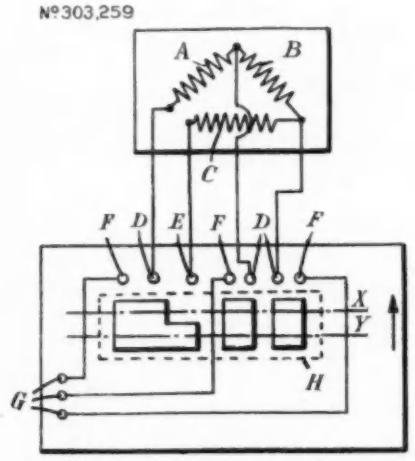

these switch contacts D and E, there are three switch contacts F connected respectively to three terminals G for the supply. A movable switch member indicated at H, which has three conducting plates, is shown in the "off" position, and is moved upwardly to start the motor. This upward movement is arranged to be effected in two steps. At the first step the switch contacts D, E, and F occupy a position with respect to the plates, as indicated by the line X. The two windings A and B are thus energised from the three lines of the supply, but the winding C is not energised as the switch contact E is still unconnected at this stage. In the second step of the movement of the member H the switch contacts take up a position indicated by the line Y, and the winding C will then be connected to the winding A and to the supply without disconnecting the windings A and B.—*January 3rd*, 1929.

TRANSFORMERS AND CONVERTERS.

303,320. April 23rd, 1928.—IMPROVEMENTS IN ELECTRICAL TRANSFORMERS, *George William Johnson, of 47, Lincoln's Inn-fields, London.*

In accordance with this invention a single or polyphase transformer with a closed magnetic circuit and primary and

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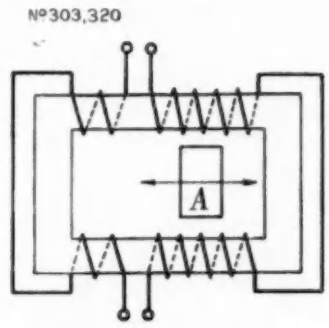

secondary windings, is provided with one or more magnetic shunts A, which regulate the leakage between the two windings by movement in one or the other directions, as indicated by the arrow. Several alternative schemes all involving the use of magnetic shunts are described.—*January 2nd*, 1929.

TELEGRAPHS AND TELEPHONES.

302,634. September 19th, 1927.—IMPROVEMENTS IN RADIO SIGNALLING SYSTEMS, Standard Telephones and Cables, Ltd., of Connaught House, Aldwych, London, W.C. 2.

This invention relates to radio signalling systems, and comprises an arrangement for separately receiving first one component of transmitted signals and then another component of the transmitted signals polarised, preferably in a different plane, so that the received components may be combined in proper phase relationship without previous rectification in order that the signalling currents may be reproduced. Two stations are shown, a transmitting station A and a receiving station B. The transmitting station comprises a transmitter C, preferably transmitting high-frequency electrical waves with suitable modulations of signalling current. The transmitter C

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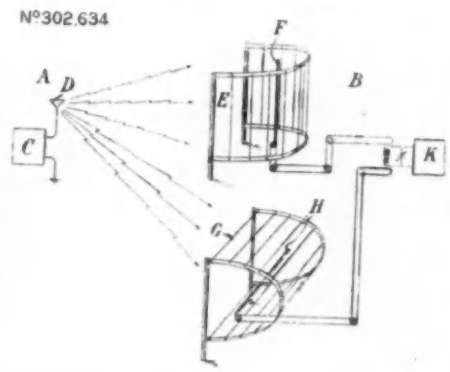

connected to an antenna D. At the receiving station B there are two antenna structures, one of which is preferably arranged with its axis vertical and the other of which is preferably arranged with its axis horizontal. The vertical antenna structure is near the horizontal antenna structure. The vertical antenna structure comprises preferably a parabolic array consisting of elements E, all arranged on a parabolic surface around an aerial F, often called a resonator, as a focus. The horizontal antenna structure comprises a parabolic array also consisting of elements G all arranged on a parabolic surface around a resonator H as a focus. These parabolic antenna structures are employed for their directive properties in order to increase the received signal strength. The radio waves are impressed upon a receiver K, from which the signals may be derived and, if desired, amplified to any desirable amount.—*December 19th*, 1928.

302,715. September 21st, 1927.—ELECTRIC CIRCUITS EMPLOYING THERMIONIC VALVES, Collinson's Precision Screw Company, Ltd., and Francis Edward Collinson, both of Provost Works, Macdonald-road, Walthamstow, London, E. 17.

In accordance with this invention the screens A of the valves are connected together and to one terminal of a variable resistance B. The other terminal of this

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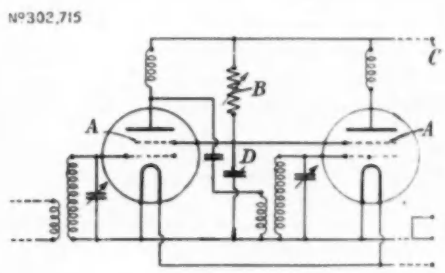


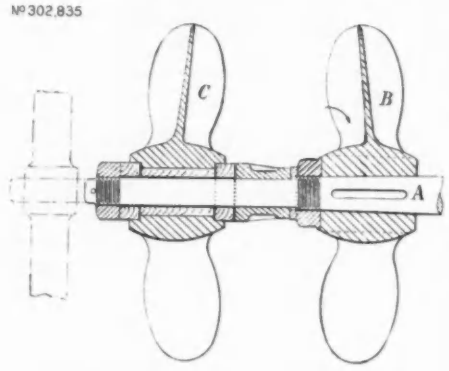
resistance is connected to the terminal C for the positive high-tension supply. A by-pass condenser D is preferably connected between the coupled screens and the filaments of the valves and in some arrangements such a condenser may be provided for each valve in order to permit short leads between a condenser and a valve. The resistance B is preferably variable

between values of 10,000 ohms and at least 250,000 ohms. The provision of the variable resistance affords a convenient and critical control of the potential applied to the screens A, and such a control is advantageous for the correct and efficient operation of thermionic valve apparatus employing screened valves. The necessity for a separate tapping on the battery or other source of high-tension supply is obviated, and any alteration in the high-tension supply pressure will not materially affect the relationship between screen and anode potentials for satisfactory operation of the valve.—*December 21st*, 1928.

SHIPS AND BOATS.

302,835. February 18th, 1928.—COUNTER-PROPELLERS FOR MARINE, SUBMARINE AND AERIAL CRAFT. John de Meo, of 39, Coventry-street, London, W. 1.

This invention relates to the propulsion of ships, vessels and aircraft, submarines or seaplanes. It has been found by the inventor that an improvement in the propelling efficiency of screw propellers may be obtained by adopting a counter-screw-propeller for use with an ordinary screw propeller. The

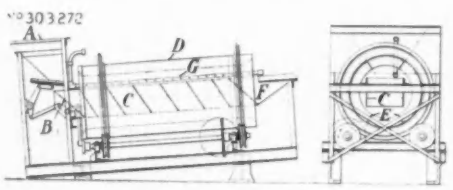


counter-propeller acts in the inverse sense of rotation to that of the main screw-propeller. The main driving shaft is formed to fit the usual tapered seat formed in the boss of the main propeller B, and this is keyed on the shaft as shown. The blades of the counter propeller are indicated at C. The latter propeller is mounted loosely so as to rotate freely and indepenently of the main propeller, but it may be keyed to a propeller-shaft in the case in which the counter-propeller-shaft may be arranged to rotate independently.—*December 27th*, 1928.

MISCELLANEOUS.

303,272. December 31st, 1927.—GRAVEL-WASHING MACHINES. C. Gaukroger Hodgson, and Millars' Machinery Company, Ltd., Pinners' Hall, Great Winchester-street, London, E.C. 2.

In this rotary washer the material to be cleaned is moved



forward uphill towards the outlet. The gravel, for instance, is fed from the hopper A on to the inclined plate B in the box C, which runs throughout the length of the drum D. Falling out at the bottom of the box, the gravel is picked up by the blades E attached to the rotating drum, and is lifted up into the next sloping compartment of the box. In this way it is fed forward to the outlet F. During the process water is sprayed on to the gravel by the perforated pipe G. The consequence is that muddy material is washed away to the lower outlet, while the gravel is laved by increasingly clean water, as it rises up the drum to its outlet.—*January 3rd*, 1929.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

CHEMICAL ENGINEERING GROUP.—In the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. "The *Rôle* of Surface Energy in Chemical Engineering," by Professor W. E. Gibbs. 8 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—In the Non-ferrous Section of the Applied Science Department of the University, St. George's-square, Sheffield. "Some Recent Developments in Nickel Metallurgy," by Mr. W. T. Griffiths. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—At the Queen's Hotel, Coventry. Annual dinner of the Coventry Graduates.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, London, S.W. 1. Informal meeting. "The Profession of the Mechanical Engineer," special discussion introduced by Mr. L. A. Legros. 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: NORTH-EASTERN STUDENTS' SECTION.—Armstrong College, Newcastle-on-Tyne. Paper, "The City of Winnipeg Hydro-electric Installation," by Mr. S. Gibson. 7.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND STUDENTS' SECTION.—The University, Edmund-street, Birmingham. Paper, "Hydro-electric Stations of Switzerland," by Mr. P. E. Lyddon. 7.15 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, Westminster, S.W. 1. "Recent Developments in the Art of Oil Cracking," by Dr. A. E. Dunston. 7.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Room 14, Temperance Institute, Keighley. Joint meeting with the Keighley Textile Society. Lecture, "Comparative Advantages of Private Generating Plant or Purchased Power," by Messrs. K. A. Mountain and A. B. MacLean. 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS.—The Engineers' Club, Albert-square, Manchester. Paper, "Engineering in the Chemical Industry," by Mr. C. E. S. Place. 7.15 p.m.

PHYSICAL SOCIETY.—Imperial College of Science, South Kensington, London, S.W. 7. Papers, "The Construction and Calibration of a Sensitive Form of Pirani Gauge for the Measurement of High Vacua," by Mr. L. F. Stanley; "The Photographic Measurement of the Relative Intensities of the La_1, La_2, La_3 Lines of Silver" and "Spark Satellites of the *La* Lines of Silver," by Mr. H. C. Webster. A demonstration of a new instrument for the rapid and accurate determination of the specific gravities of solid substances will be given by Mr. W. A. Benton, Head of Research Department, Messrs. W. and T. Avery, Ltd. 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, W. 1. Discourse, "Recent Problems of Rail Transport at Home and Abroad," by Mr. C. E. R. Sherrington. 9 p.m.

SATURDAY, FEBRUARY 9TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Annual dinner of the London Graduates at Les Gobelins Restaurant, Heddon-street, Regent-street, W. 1. 7 p.m.

MONDAY, FEBRUARY 11TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—At the Queen's Hotel, Birmingham. "Coil Ignition," by Dr. F. W. Lanchester. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING. The College, Loughborough. "Supercharging," by Mr. F. Elster. 7 p.m.

INSTITUTION OF SANITARY ENGINEERS.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Subaqueous Tunnelling in Compressed Air," by Mr. J. A. Formunt. 7.30 p.m.

TUESDAY, FEBRUARY 12TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, BURNLEY SECTION.—Lecture Room of the Municipal College, Burnley. "Some Aspects of Modern Foundry Practice," by Mr. Griffiths. 7.15 p.m.

INSTITUTE OF MARINE ENGINEERS.—85-88, The Minories, Tower-hill, London, E. 1. "The Design and Construction of Electric Auxiliaries for Marine Service," by Mr. G. J. Scott. 6.30 p.m.

INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—In the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. "Metallurgy of Engineering," by Mr. J. E. Newson. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—General meeting at the Rover Sports Club, Albany-road, Coventry. "Coil Ignition," by Dr. F. W. Lanchester. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS; SCOTTISH CENTRE.—The Societies' Room, the Royal Technical College, George-street, Glasgow, C. 1. Paper, "Overhead Electric Lines," by Mr. W. B. Woodhouse. 7.30 p.m.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Chemical Investigation of Trinidad Well Waters, and its Geological and Economical Significance," by Messrs. J. S. Parker and C. A. P. Southwell. 5.30 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION.—198, West-street, Sheffield. "Metallurgical Post-mortem Examinations," by Mr. A. Parker Hague. 7.30 p.m.

WEDNESDAY, FEBRUARY 13TH.

ILLUMINATING ENGINEERING SOCIETY.—Trocadero Restaurant, Piccadilly, London, W. 1. Twentieth anniversary dinner. 7.30 p.m.

INSTITUTE OF FUEL.—Chemical Society's Rooms, Burlington House, Piccadilly, London, W. 1. Paper, "Fuel Economy and the Small Steam User," by Mr. W. F. Goodrich. 6 p.m.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—In the Thomas' Café, High-street, Swansea. "Recent Developments in Rolling Metal Strip and Sheet," by Mr. J. E. Malam. 7 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W. 1. Informal meeting. Subject for discussion, "Merits of Alternative Methods of Driving Auxiliaries in Modern Power Stations," by Mr. Harry Philip Gaze, M. Inst. C.E. 6 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE.—St. Bride Institute, Bride-lane, Fleet-street, London, E.C. 4. Paper, "Developments of Road Transport and Considerations Affecting Mechanical Road Transport under Modern Conditions," by Mr. J. B. Osler. 7.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Holborn Restaurant, London, W.C. 1. Annual general meeting. Paper, "Water Softening by the Base Exchange Process," by Mr. H. G. Catheart. 2.30 p.m.

THURSDAY, FEBRUARY 14TH.

INSTITUTE OF METALS: LONDON LOCAL SECTION.—In the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W. 1. "Some Present-day Metallurgical 'Tools' and Methods:" "The X-ray Spectrometer," by Dr. C. J. Smithells; "Quantitative Spectroscope Analysis," by Mr. S. V. Williams; "High Magnification Microscopy," by Mr. H. Wrighton; "Dilatometers," by Mr. W. E. Prytherch; "Preparation of Some Unusual Metallographic Specimens," by Mr. A. J. Murphy. 7.30 p.m.

INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Joint meeting with the Institution of Engineers and Shipbuilders and the Institute of British Foundrymen, in the Rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Alloys: Past, Present, and Future," by Dr. W. Rosenhain, F.R.S. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Joint meeting with the Royal Aeronautical Society at the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Air-cooled Engines in Service," by Mr. A. H. R. Fedden. 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING.—Cavendish Café, Cornmarket, Derby. "Modern Methods of Engineering Inspection," by Mr. C. D. Ricketts. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Paper, "Voice-frequency Telegraphs," by Mr. W. Cruickshank. 6 p.m.

OPTICAL SOCIETY.—Imperial College of Science and Technology, South Kensington, London, S.W. 7. Paper, "An Application of the Interferometer to the Goniometry of Prisms," by Mr. D. S. Perfect. Demonstration of "Professor Coker's Photo-elestic Apparatus (1928 Model)," by Messrs. Adam Hilger, Ltd. 7.30 p.m.

ROYAL AERONAUTICAL SOCIETY.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "Air-cooled Engines in Service," by Mr. A. H. R. Fedden. 7.45 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. "The Early History of X-Rays," by Sir Wm. Bragg, F.R.S. 5.15 p.m.

THURSDAY AND FRIDAY, FEBRUARY 14TH AND 15TH.

INDUSTRIAL WELFARE SOCIETY (INCORPORATED).—Hotel Victoria (Edward VII. Rooms), Northumberland-avenue. A Conference on Industrial Canteen Management. 10.15 a.m. each day.

FRIDAY, FEBRUARY 15TH.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Annual general meeting. Paper, "Refrigeration on Shipboard," by Mr. H. J. Ward. 6 p.m.

INSTITUTION OF PROFESSIONAL CIVIL SERVANTS.—Surveyors' Institution, 12, Great George-street, London, S.W. 1. Lecture, "Salvaging the Fleet at Scapa Flow," by Mr. G. Atkinson. 5.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Informal meeting. "Steam Storage," by Mr. E. G. Ritchie. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Chemi-Luminescence," by Dr. E. K. Rideal. 9 p.m.

WEST BROMWICH ENGINEERING SOCIETY.—Kenrick Technica College, West Bromwich. Address, "A Business Man's World Tour," by Mr. W. W. Hackett. 7.30 p.m.

SATURDAY, FEBRUARY 16TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Beverley, Yorks. Yorkshire District meeting. 11.15 a.m.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to the Air Port of London, Croydon. 2.30 p.m.

MONDAY, FEBRUARY 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Royal Technical College, Glasgow. "Some Investigations into the Performance of Tubular Radiators for Motor Vehicles," by Mr. H. Kerr Thomas. 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' SECTION.—Storey's-gate, Westminster, London, S.W. 1. Paper, "Railway Brakes," by Mr. G. Bird. 6.30 p.m.

MONDAY, FEBRUARY 18TH, TO FRIDAY, MARCH 1ST.

BRITISH INDUSTRIES FAIR.—White City, London, 10 a.m. to 8 p.m. daily; and Castle Bromwich, Birmingham, 10 a.m. to 6 p.m. daily.

TUESDAY, FEBRUARY 19TH.

INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Joint meeting with the Birmingham Metallurgical Society and the Staffordshire Iron and Steel Institute, in the Engineers' Club, Waterloo-street, Birmingham. "Fuel," by Mr. E. C. Evans. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Broadgate Café Coventry. Graduates Meeting. Address by Mr. H. R. Ricardo. 7.15 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING.—The College, Loughborough. Engineering Films. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Engineering and Scientific Club, Wolverhampton. "Some Investigations into the Performance of Tubular Radiators for Motor Vehicles," by Mr. H. Kerr Thomas. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, London, S.W. 1. Paper, "The Electrical Heating and Ventilation of Bourne and Hollingsworth's Premises, Oxford-street," by Mr. A. H. Barker. 6 p.m.

WEDNESDAY, FEBRUARY 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS: BIRMINGHAM GRADUATES.—At the Queen's Hotel, Birmingham. "Valve Gear for High-speed Singles," by Mr. E. M. Frank. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "The Purification of Water," by Major T. H. Bishop. 8 p.m.

THURSDAY, FEBRUARY 21ST.

INSTITUTION OF AUTOMOBILE ENGINEERS: LONDON GRADUATES.—At Watergate House, Adelphi, W.C. 2. "Some Notes on Gear Production," by Mr. C. Russell. 7.25 p.m.

FRIDAY, FEBRUARY 22ND.

INSTITUTION OF LOCOMOTIVE ENGINEERS: NORTH-EASTERN CENTRE.—Hotel Metropole, Leeds. "Reduction of Weight in Rolling Stock," by Mr. G. H. Taylor. 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Paper, "The Application of the Heavy Oil Engine to Yachts and Small Craft," by Mr. J. Calderwood. 7.30 p.m.

SATURDAY, FEBRUARY 23RD.

INSTITUTE OF BRITISH FOUNDRYMEN.—Grand Hotel, Manchester. Annual dinner.

WEDNESDAY, FEBRUARY 27TH.

INSTITUTION OF AUTOMOBILE ENGINEERS: NORTH OF ENGLAND CENTRE.—Engineers' Club, Albert-square, Manchester. "Some Investigations into the Performance of Tubular Radiators for Motor Vehicles," by Mr. H. Kerr Thomas. 7 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "Resins," by Mr. A. F. Suter. 8 p.m.

THURSDAY, FEBRUARY 28TH.

INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Joint meeting with the Birmingham Metallurgical Society and the Staffordshire Iron and Steel Institute, in the Engineers' Club, Waterloo-street, Birmingham. "Metallurgy and the Evolution of the Balance," by Mr. W. A. Bentow. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES.—King's Café, St. Peter's-street, Derby. Annual dinner.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING.—Royal Hotel, Mill-street, Luton. "Some Notes on Gear-box Design," by Mr. G. Baston. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Queen's Hotel, Birmingham. Annual dinner. 7 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Town Hall, Southall, Middlesex. South Midland District Meeting. 10.45 a.m.

FRIDAY, MARCH 1ST.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING.—Regent Restaurant, 51, West Regent-street, Glasgow. "Inspection," by Mr. E. C. Philbrow. 8 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Frascati Restaurant, London. Annual dinner. 7 p.m.

MONDAY, MARCH 4TH.

INSTITUTION OF AUTOMOBILE ENGINEERS: GRADUATES' MEETING.—The College, Loughborough. "Lubrication," by Mr. G. L. B. Hall. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WESTERN CENTRE.—Merchant Venturers' Technical College, Bristol. "Air-cooled Engine Repairs and Lay-out," by Mr. A. H. R. Fedden. 6.45 p.m.

TUESDAY, MARCH 5TH.

INSTITUTION OF AUTOMOBILE ENGINEERS: GENERAL MEETING.—At the Royal Society of Arts, John-street, Adelphi, W.C. 2. 7.45 p.m.